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ABSTRACT

This document consists of 37 draft curriculum maps and 3 curricula that were developed to enable vocational students to make a smooth transition from their high school vocational program to an associate degree or vocational diploma program at Blackhawk Technical College in Wisconsin. The career maps outline the reading, mathematics, and other skills/skill levels and high school- and technical college-level course sequences required of students pursuing the given career path. Next, 15 entry-level communication competencies required of all tech prep students are listed. The remainder of the guide consists of three 4-week technical college-level competency-based courses in the following subjects: applied mathematics (basic arithmetic operations, quality assurance, statistics, measurement, scientific notation, and trigonometry); science (food science; avionics/hydraulics; the chemical breakdown of foodstuffs, gas laws and laboratory procedures, and an overview of anatomy; and force and motion); and communications (basic communication, business correspondence, and report-writing skills as related to occupations in food science, aviation, allied health, and mechanical design). Each curriculum guide contains some or all of the following: syllabus, behavioral objectives, background information, instructional handouts, and learning activities. (MN)

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ED 376 299

BLACKHAWK TECHNICAL COLLEGE

CURRICULUM DEVELOPED THROUGH PROJECT
05-485-150-613
SERVICES TO THE DISADVANTAGED-CURRICULUM DEVELOPMENT
FY 1992-93

U.S. DEPARTMENT OF EDUCATION
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ACCOUNTING
ASSOCIATE DEGREE

The recommended reading level for the above program should be 11th grade. This is based on:

Readability level of textbook(s): 10-12th grade

Related communication competencies:

1. Reading comprehension
2. Analyze and assimilate written material
3. Organize information
4. Analyze, summarize and communicate data and information in a concise, coherent manner

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:

Basic math skills: add, subtract, divide, multiply
Interest and tax calculations
Financial statements and analysis
Statistics
Formulate and solve equations

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

Integrity
Abstract thinking
Problem solving: Basic Algebra
Able to work with others
Knowing how to learn
Work with details accurately

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ACCOUNTING
(ASSOCIATE DEGREE)

MAPPING STRATEGIES

	HIGH SCHOOL				BLACKHAWK TECHNICAL COLLEGE			
SUBJECT	FRESHMAN	SOPHOMORE	JUNIOR	SENIOR	SEMESTER 1	SEMESTER 2	SEMESTER 3	SEMESTER 4
MATH	Algebra	Business Math			Business Math; Accounting I	Accounting II;	Accounting III; Spreadhsheets	Accounting IV
ENGLISH	English 9	English 10	English 11	English 12	Written Communications	Oral Communications; Interpersonal		
SCIENCE								
SOCIAL STUDIES	3 credits				Psychology of Human Relations; Contemporary Society			Economics
OTHER	KEYBOARDING/COMPUTER SCIENCE				Keyboarding; Payroll/Principles of Data Processing			
RECOMMENDED TECHNICAL SUPPORT	Accounting I							

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ACCOUNTING ASSISTANT
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 11th -12th grade. This is based on:

Readability level of textbook(s):
- Complete Computer Concepts 13

Related communication competencies:
- Read textbooks and manuals
- Create documents, reports, graphs
- Listen and receive directives

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
- Invoicing, depreciation, rate of return
- Interest, commission, tax returns
- Billing, inventory, taxes, statistics
- Present value, future values statements

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
- Keyboarding
- Algebra
- Participate as team member
- Knowing how to learn

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ACCOUNTING ASSISTANT
(VOCATIONAL DIPLOMA)

MAPPING STRATEGIES

	HIGH SCHOOL				BLACKHAWK TECHNICAL COLLEGE			
SUBJECT	FRESHMAN	SOPHOMORE	JUNIOR	SENIOR	SEMESTER 1	SEMESTER 2	SEMESTER 3	SEMESTER 4
MATH	Algebra	Business Math			Business Math Recordkeeping I	Payroll Accounting Recordkeeping II		
ENGLISH	English 9	English 10	English 11	English 12	Business Communications I	Business Communications II		
SCIENCE								
SOCIAL STUDIES	3 credits				Human Relations	Applied Economics		
OTHER	KEYBOARDING/COMPUTER SCIENCE				Typing I Principles of Data Processig	Information Processing		
RECOMMENDED TECHNICAL SUPPORT								

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ADMINISTRATIVE ASSISTANT - SECRETARIAL
ASSOCIATE DEGREE

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):
Need to check with instructors who teach most of these courses. My book is at 10th grade level.

Related communication competencies:
- Spelling
- Grammar
- Punctuation
- Interpersonal skills
- Listening skills

The recommended math level should be 9th grade. This is based on:

Competencies requiring computation:
- Basic computational skills

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
- Understand and interpret written and oral communication
- Organizational skills
- Flexibility
- Composition skills
- Good business ethics
- Maturity
- Leadership skills

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ADMINISTRATIVE ASSISTANT - SECRETARIAL
(ASSOCIATE DEGREE)

MAPPING STRATEGIES

	HIGH SCHOOL				BLACKHAWK TECHNICAL COLLEGE			
SUBJECT	FRESHMAN	SOPHOMORE	JUNIOR	SENIOR	SEMESTER 1	SEMESTER 2	SEMESTER 3	SEMESTER 4
MATH	Business Math				Business Math		Accounting - Secretarial	Records Management
ENGLISH	English 9	English 10	English 11	English 12	Secretarial Communications I	Secretarial Communications II		
SCIENCE								
SOCIAL STUDIES	3 credits				Professional Profiles		Contemporary Society Economics	Psychology of Human Relations
OTHER	KEYBOARDING/COMPUTER SCIENCE				Typing II	Typing III	Word Processing Applications	Machine Transciption
RECOMMENDED TECHNICAL SUPPORT								

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AVIONICS TECHNOLOGY
ASSOCIATE DEGREE

The recommended reading level for the above program should be 10h grade. This is based on:

Readability level of textbook(s): 10th
- Comprehension of Technical Manuals
- Following Detail Instructions

Related communication competencies:
- Interpersonal Communications/Teamwork
- Customer Relation Skills
- Telephone Communications
- Computer Communications/Modem
- Graphical Communications

The recommended math level should be 10h grade. This is based on:

Competencies requiring computation:
- Basic Algebra, Advanced Algebra, Geometry, Trigonometry
- To solve electronic circuit problems and use of calculators to pass license exams

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

- Must be interested in airplanes, aviation and flying
- Basic computer skills
- Excellent eyesight for working in low light level
- Be able to work in confining spaces
- Excellent mechanical skills
- Be able to work outside in the weather
- Be able to tolerate loud sound levels
- Be able to see colors

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AVIONICS TECHNOLOGY

MAPPING STRATEGIES

	HIGH SCHOOL				BLACKHAWK TECHNICAL COLLEGE			
SUBJECT	FRESHMAN	SOPHOMORE	JUNIOR	SENIOR	SEMESTER 1	SEMESTER 2	SEMESTER 3	SEMESTER 4
MATH	Algebra				Applied Math			
ENGLISH	English 9	English 10			Written Communications	Oral & Interpersonal Communications		
SCIENCE			Applied or General Science		Fund of DC	Fund of AC		
SOCIAL STUDIES	3 credits				Psychology of Human Relations		Contemporary Society	Economics
OTHER	KEYBOARDING/COMPUTER SCIENCE (Introductory Level)							
RECOMMENDED TECHNICAL SUPPORT	Geometry Advanced Algebra Trigonometry Technology Education Chemistry Physics							

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AIRFRAME AND POWERPLANT MECHANIC
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 12th grade. This is based on:

Readability level of textbook(s):
FAA Advisory circulars containing related information was tested at 14th grade level.

Related communication competencies:
Written communication in regards to log books and reports
Oral communications in regards to radio procedure
Clear, concise writing; confidence in ability to speak

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
Weight and balance, electrical computations require mostly add, subtract, multiply and divide. Basic algebra: order of procedures, etc. Fractions, percents, ratios, charts and graphs.

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

*Physics: relationships of temp, press, velocity
Current voltage and resistance; aerodynamics; applied math, stresses, sound temperature, energy
*Graphical communication sketching, drafting
*Small engine theory and application
*Chemistry: basic chemicals, hazardous materials, chemical handling and safety
*Computer skills; ability to use software
*Wood working
*Metal working
*Use of hand and power tools
*Airway sciences
*Technical education
*Auto Mechanic Engine Technical
    *Carburetion
    *Fuel Injection
    *Lubricating systems for engines-auto
    *Machine shop
    *Auto body
    *Welding

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AIRFRAME & POWERPLANT MECHANIC
(VOCATIONAL DIPLOMA)

MAPPING STRATEGIES

	HIGH SCHOOL				BLACKHAWK TECHNICAL COLLEGE			
SUBJECT	FRESHMAN	SOPHOMORE	JUNIOR	SENIOR	SEMESTER 1	SEMESTER 2	SEMESTER 3	SEMESTER 4
MATH	Algebra	Geometry			Aviation Applied Math			
ENGLISH	English 9	English 10	English 11	English 12			Communications I	
SCIENCE			Chemistry	Physics		Aviation Applied Physics		
SOCIAL STUDIES	3 credits							Human Relations
OTHER	KEYBOARDING/COMPUTER SCIENCE							
RECOMMENDED TECHNICAL SUPPORT					Airway Science (if available) Tech Ed (all areas) Trigonometry			

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AUTO BODY REPAIR & PAINT TECHNICIAN
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 11th grade. This is based on:

Readability level of textbook(s):
- Theory and/or concept texts - 12th grade
- Reference Manuals
- Tech Manuals
- Charts
- Basic Electricity - Schematics

Related communication competencies:
- Customer relations (appearance, conflict resolution)
- Peer Relations (compatibility)
- Telephone Skills
- Computer Literacy
- Keyboarding Skill
- Follow Directives

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
- Addition
- Subtraction
- Multiplication
- Percentages
- Ratio
- Elementary Physics
- Basic Geometry
- Measuring (inch and metric)

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

- Safety - self
- Hazardous materials
- Quality of Performance
- Speed of Performance
- Attendance (completion, punctuality)
- Posture (responsible, dependable, works to completion)

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AUTO BODY REPAIR & PAINT TECHNICIAN
(VOCATIONAL DIPLOMA)

MAPPING STRATEGIES

	HIGH SCHOOL				BLACKHAWK TECHNICAL COLLEGE			
SUBJECT	FRESHMAN	SOPHOMORE	JUNIOR	SENIOR	SEMESTER 1	SEMESTER 2	SEMESTER 3	SEMESTER 4
MATH	General Math	General Math			Business Math			
ENGLISH	English 9	English 10	English 11	English 12	Communications I			
SCIENCE								
SOCIAL STUDIES	3 credits				Human Relations			
OTHER	KEYBOARDING/COMPUTER SCIENCE							
RECOMMENDED TECHNICAL SUPPORT	Technical Education							

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AUTOMOTIVE TECHNICIAN
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 12th grade. This is based on:

- Readability level of textbook(s):
  - Service Manuals
  - Technical Manuals
  - Reference Materials
  - 10th Grade Textbook
- Related communication competencies:
  - Interpret Charts
  - Writing Repair Order
  - Customer Relations
  - Telephone Etiquette
  - Keyboard Skills
  - Listening & Questioning Skills
  - Follow Written Directions
  - Problem Solving Skills (logical thinking)
  - Conflict Resolution (management)

The recommended math level should be 10th grade. This is based on:

- Competencies requiring computation:
  - Measuring
  - Metric & Conversions
  - Fractions 1/64
  - Decimals .000001
  - Temperature - F° & C°
  - Graphs (bar/line)
  - Torque
  - Physics - Practical
  - Area - Volume - Mass - Weight
  - Simple/Complex Machines
  - Density - mass Air Flow
  - Specific Gravity
  - Basic Electricity (DC & AC; Volt - Amp - Resist.; Watt; Series/Parallel Circuits

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

- Safety
- Manual Dexterity (left and right)
- Attendance
- Punctuality
- Appearance (professional image)
- Follows Instruction (written/oral)
- Demonstrates Problem Solving Skills
- Completion of Task(s) in a Timely Manner
- Ability to Accept Criticism and Modify Behavior
- Understanding & Acceptance of Other Cultures

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AUTOMOTIVE TECHNICIAN
(VOCATIONAL DIPLOMA)

MAPPING STRATEGIES

	HIGH SCHOOL				BLACKHAWK TECHNICAL COLLEGE			
SUBJECT	FRESHMAN	SOPHOMORE	JUNIOR	SENIOR	SEMESTER 1	SEMESTER 2	SEMESTER 3	SEMESTER 4
MATH	Algebra	Geometry			Shop Math I	Shop Math II		
ENGLISH	English 9	English 10	English 11	English 12	Communications I	Communications II		
SCIENCE			Chemistry	Physics	Applied Science			
SOCIAL STUDIES	3 credits					Applied Economics	Customer Relations	
OTHER	KEYBOARDING/COMPUTER SCIENCE							
RECOMMENDED TECHNICAL SUPPORT	Technical Education							

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CHILD CARE SERVICES
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s): from 10th to 12th grade level.

Related communication competencies:
Written communication skills are needed for parent communication.
Effective verbal communication skills are needed to provide a role-model for children to learn from.

The recommended math level should be 6th grade. This is based on: the knowledge of basic math that the students will need to know in order to do and present math activities with children.

Competencies requiring computation: basic arithmetic

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

1. Decision making and problem solving skills.
2. Need interpersonal skills
3. Is capable of taking a leadership role.
4. Interprets and communicates information.
5. Records information accurately and timely.
6. Maintains confidential information.
7. Need to be agile enough to get up and down from the floor and to be able to life and transfer children.

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CHILD CARE SERVICES
(VOCATIONAL DIPLOMA)

MAPPING STRATEGIES

	HIGH SCHOOL				BLACKHAWK TECHNICAL COLLEGE			
SUBJECT	FRESHMAN	SOPHOMORE	JUNIOR	SENIOR	SEMESTER 1	SEMESTER 2	SEMESTER 3	SEMESTER 4
MATH								
ENGLISH	English 9	English 10	English 11	English 12	Communications I	Communications II		
SCIENCE								
SOCIAL STUDIES	3 credits				Human Relations			
OTHER	KEYBOARDING/COMPUTER SCIENCE							
RECOMMENDED TECHNICAL SUPPORT	Child Growth & Development							

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CULINARY ARTS
(ASSOCIATE DEGREE)

MAPPING STRATEGIES

	HIGH SCHOOL				BLACKHAWK TECHNICAL COLLEGE			
SUBJECT	FRESHMAN	SOPHOMORE	JUNIOR	SENIOR	SEMESTER 1	SEMESTER 2	SEMESTER 3	SEMESTER 4
MATH	Algebra	Geometry			Orientation To Quantity Food Preparation* Business Math			Business Administration/Accounting; Food Purchasing; Inventory Cost Control
ENGLISH	English 9	English 10	English 11	English 12	Written Communications	Oral Communications		
SCIENCE					Food Science; Safety & Sanitation	Nutriton		
SOCIAL STUDIES	3 credits						Psychology of Human Relations	Economics; Industrial Psychology
OTHER	KEYBOARDING/COMPUTER SCIENCE							
RECOMMENDED TECHNICAL SUPPORT	Chemistry/Foods							

*Articulation with Albany, Beloit Turner, Beloit Memorial, Evansville

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CULINARY ARTS
ASSOCIATE DEGREE

The recommended reading level for the above program should be 10th grade. This is based on: Readability Test.

Readability level of textbook(s):
- Foundations of Food Preparations
- Applied Food Service Sanitation

Related communication competencies:

The recommended math level should be 9th grade. This is based on:

Competencies requiring computation:
- Cost accounting
- Recipe/ingredient calculations
- Menu planning

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

Dexterity with right and left hand
Ability to problem-solve

Date: 10/9.

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CULINARY ARTS
ASSOCIATE DEGREE

The recommended reading level for the above program should be 10th grade. This is based on: Readability Test.

Readability level of textbook(s):
- Foundations of Food Preparations
- Applied Food Service Sanitation

Related communication competencies:

The recommended math level should be 9th grade. This is based on:

Competencies requiring computation:
- Cost accounting
- Recipe/ingredient calculations
- Menu planning

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

- Dexterity with right and left hand
- Ability to problem-solve

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COMPUTER INFORMATION SYSTEMS/PROGRAMMER ANALYST
ASSOCIATE DEGREE

The recommended reading level for the above program should be 14th average grade. This is based on:

Readability level of textbook(s):
- 1st year texts are Freshman level college
- 2nd year texts are Junior/Senior level college

Related communication competencies:
- Strong written skills - written instructions
- Listening skills - perform from verbal inst.
- Oral skills - present ideas/designs
- Organization skills - organize info in a sequential/hierarch order

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
- Problem solving and deductive reasoning

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

- Problem solving - formal and informal
  - -flowcharts
  - -word problems
  - -instructions
- Analytical skills - analyze a problem and design a solution

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DENTAL ASSISTANT
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):
Most are at 10th grade, one is at 12th grade

Related communication competencies:

1. Good oral grammar when working with Dentists, patients, and professionals
2. Good writing skills (spelling and sentence structure) for dental charts and letters

The recommended math level should be 9th grade. This is based on: Basic accounting content

Competencies requiring computation:
Reconciling bank statements, accounts payable, receivable, payroll and insurance benefits

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

1. Right and left hand dexterity
2. Good eye to hand coordination
3. Accurate depth perception
4. Good science background helpful
5. Ability to follow written and oral instruction
6. Agility
7. Ability to occasionally lift heavy objects

Date: 10/92

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DENTAL ASSISTANT
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):
Most are at 10th grade, one is at 12th grade

Related communication competencies:

1. Good oral grammar when working with Dentists, patients, and professionals
2. Good writing skills (spelling and sentence structure) for dental charts and letters

The recommended math level should be 9th grade. This is based on: Basic accounting content

Competencies requiring computation:
Reconciling bank statements, accounts payable, receivable, payroll and insurance benefits

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

1. Right and left hand dexterity
2. Good eye to hand coordination
3. Accurate depth perception
4. Good science background helpful
5. Ability to follow written and oral instruction
6. Agility
7. Ability to occasionally lift heavy objects

Date: 10/92

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DIESEL AND HEAVY EQUIPMENT TECHNICIAN
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 9th grade. This is based on:

Readability level of textbook(s):
- Service Manuals
- Technical Manuals

Related communication competencies:
- Follow instructions
- Safety conscious
- Work cooperatively
- Good mechanical aptitude
- Chart
- Repair orders

The recommended math level should be 9th grade. This is based on:

Competencies requiring computation:
- Hydraulic force
- Measures
- Metrics
- Temp F.-C.
- Torques
- Basic electrical

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
- Works well with people
- Good mechanical aptitude
- Good attendance

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DIESEL AND HEAVY EQUIPMENT TECHNICIAN
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 9th grade. This is based on:

Readability level of textbook(s):
  Service Manuals
  Technical Manuals

Related communication competencies:
  Follow instructions
  Safety conscious
  Work cooperatively
  Good mechanical aptitude
  Chart
  Repair orders

The recommended math level should be 9th grade. This is based on:

Competencies requiring computation:
  Hydraulic force
  Measures
  Metrics
  Temp F.-C.
  Torques
  Basic electrical

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
  Works well with people
  Good mechanical aptitude
  Good attendance

Date: 10/92

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ELECTRIC POWER DISTRIBUTION
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 11th grade. This is based on:

Readability level of textbook(s):
- Electrical theory books and publications written by engineers, physicists and electronic technicians.
- Math books - higher mathematics level - advanced algebra, trigonometry, etc.

Related communication competencies:
- Receive and give oral communications
- Read, write and follow written rules and regulations
- Work and associate with people of all levels (engineers and architects on the job - home owners has all categories)

The recommended math level should be 11th grade. This is based on:

Competencies requiring computation:
- Working knowledge using fractions - decimals - basic algebra
- Ability to use exponents (squares, powers of ten, etc.)
- Trig functions and pythagorean theory as they apply to alternating current fundamentals and applications in pipe bending

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
- Self motivation
- Physical and manual dexterity
- Knowledge and use of tools
- Knowledge of all other trade areas
- (Electricity involved in practically all aspects)

Date: 10/92

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ELECTRIC POWER DISTRIBUTION
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 11th grade. This is based on:

Readability level of textbook(s):
- Electrical theory books and publications written by engineers, physicists and electronic technicians.
- Math books - higher mathematics level - advanced algebra, trigonometry, etc.

Related communication competencies:
- Receive and give oral communications
- Read, write and follow written rules and regulations
- Work and associate with people of all levels (engineers and architects on the job - home owners has all categories)

The recommended math level should be 11th grade. This is based on:

Competencies requiring computation:
- Working knowledge using fractions - decimals - basic algebra
- Ability to use exponents (squares, powers of ten, etc.)
- Trig functions and pythagorean theory as they apply to alternating current fundamentals and applications in pipe bending

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
- Self motivation
- Physical and manual dexterity
- Knowledge and use of tools
- Knowledge of all other trade areas
- (Electricity involved in practically all aspects)

Date: 10/92

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ELECTRO MECHANICAL TECHNOLOGY
ASSOCIATE DEGREE

The recommended reading level for the above program would be 10th grade. This is based on:

Readability level of textbook(s) and related service manuals:
  Range from 10th to 13th grade

Related communication competencies:
  Be able to write complete sentences and paragraphs
  Relate symbols to the concepts they represent
  Keyboarding skills
  Interpersonal communication skills
  Customer relation skills

12th grad math level would be helpful. Recommended minimum math skills: 10th grade. This is based on.

Competencies requiring computation:
  Algebraic manipulation of formulae
  Convert decimal number to engineering, scientific and metric notation and back again
  Complex number manipulations

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

  Abstract concepts visualization needed for most jobs
  Follow safety precautions
  Basic mechanical hand tool skills
  Capability to visualize space relationships
  Good hand - eye coordination
  Mechanical aptitude
  For some entry level jobs you must not be color blind

Date: 10/92

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ELECTRO MECHANICAL TECHNOLOGY
ASSOCIATE DEGREE

The recommended reading level for the above program would be 10th grade. This is based on:

Readability level of textbook(s) and related service manuals:
  Range from 10th to 13th grade

Related communication competencies:
  Be able to write complete sentences and paragraphs
  Relate symbols to the concepts they represent
  Keyboarding skills
  Interpersonal communication skills
  Customer relation skills

12th grad math level would be helpful. Recommended minimum math skills: 10th grade. This is based on.

Competencies requiring computation:
  Algebraic manipulation of formulae
  Convert decimal number to engineering, scientific and metric notation and back again
  Complex number manipulations

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

  Abstract concepts visualization needed for most jobs
  Follow safety precautions
  Basic mechanical hand tool skills
  Capability to visualize space relationships
  Good hand - eye coordination
  Mechanical aptitude
  For some entry level jobs you must not be color blind

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ELECTRONIC TECHNOLOGY
ASSOCIATE DEGREE

The recommended reading level for the above program should be 12th grade. This is based on:

Readability level of textbook(s):
  Range from 10th to 13th grade

Related communication competencies:
  Be able to write complete sentences and paragraphs and themes.
  Relate symbols to the concepts they represent
  Keyboarding skills
  Interpersonal communication skills
  Customer relation skills

The recommended math level should be 12th grade. This is based on:

Competencies requiring computation:
  Algebraic manipulation of formulae
  Convert decimal number to engineering, scientific and metric notation and back again
  Complex number manipulations

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

  Must be able to see colors
  Must be able to visualize abstract concepts
  Follow safety precautions
  Basic mechanical hand tool skills

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ELECTRONIC TECHNOLOGY
ASSOCIATE DEGREE

The recommended reading level for the above program should be 12th grade. This is based on:

Readability level of textbook(s):
- Range from 10th to 13th grade

Related communication competencies:
- Be able to write complete sentences and paragraphs and themes.
- Relate symbols to the concepts they represent
- Keyboarding skills
- Interpersonal communication skills
- Customer relation skills

The recommended math level should be 12th grade. This is based on:

Competencies requiring computation:
- Algebraic manipulation of formulae
- Convert decimal number to engineering, scientific and metric notation and back again
- Complex number manipulations

Other skills, knowledge or attributes that may be helpful in achieving the competenci in this program:

- Must be able to see colors
- Must be able to visualize abstract concepts
- Follow safety precautions
- Basic mechanical hand tool skills

Date: 10/92

DRAFT

EMERGENCY MEDICAL TECHNICIAN
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):
    Varied levels from 10th - 17th

Related communication competencies:
    Ability to follow written instructions
    Ability to write clear, concise information/instructions
    Ability to communicate orally /in writing using proper grammar

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
    Vital signs, medications, exams - decimals, fractions, percents

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
    Good interpersonal relations - employability skills
    Current review of study skills, note taking, testing skills, etc.

Date: 10/92

DRAFT

EMERGENCY MEDICAL TECHNICIAN
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):
  Varied levels from 10th - 17th

Related communication competencies:
  Ability to follow written instructions
  Ability to write clear, concise information/instructions
  Ability to communicate orally /in writing using proper grammar

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
  Vital signs, medications, exams - decimals, fractions, percents

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
  Good interpersonal relations - employability skills
  Current review of study skills, note taking, testing skills, etc.

Date: 10/9

DRAFT

FARM BUSINESS & PRODUCTION MANAGEMENT
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):
Materials included in this program; various university extension materials; professional publications; industry publications and instructional packets

Related communication competencies:
The ability to read and follow written instructions - the same for oral instructions. The ability to write and speak clearly; the ability to write business and production plans.

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
Balancing rations; calculation for chemical and fertilizer, application; equipment calibration; area and volume calculations; weight and measures and their conversions - financial calculations

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

Biological Sciences
Chemistry
Animal Husbandry
Crops & Soils
Business Management
Bookkeeping - Records
Financial Management
Agricultural Markets & Marketing
Farm Safety
Farm Machinery & Management
Light Building Construction

Date: 10/92

DRAFT

FARM BUSINESS & PRODUCTION MANAGEMENT
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):
Materials included in this program; various university extension materials; professional publications; industry publications and instructional packets

Related communication competencies:
The ability to read and follow written instructions - the same for oral instructions. The ability to write and speak clearly; the ability to write business and production plans.

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
Balancing rations; calculation for chemical and fertilizer, application; equipment calibration; area and volume calculations; weight and measures and their conversions - financial calculations

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

Biological Sciences
Chemistry
Animal Husbandry
Crops & Soils
Business Management
Bookkeeping - Records
Financial Management
Agricultural Markets & Marketing
Farm Safety
Farm Machinery & Management
Light Building Construction

Date: 10/92

DRAFT

FIRE SCIENCE
ASSOCIATE DEGREE

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):
    Varied levels from 10th - 17th

Related communication competencies:
    Ability to follow written instructions
    Ability to write clear, concise information/instructions
    Ability to communicate orally/in writing using proper grammar

The recommended math level should be 11th grade. This is based on:

Competencies requiring computation:
    Physics principles in Fire Science

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
    Good interpersonal realtions - employability skills
    Current review of study skills, note taking, testing skills, etc.

Date: 10/92

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DRAFT

FIRE SCIENCE
ASSOCIATE DEGREE

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):
- Varied levels from 10th - 17th

Related communication competencies:
- Ability to follow written instructions
- Ability to write clear, concise information/instructions
- Ability to communicate orally/in writing using proper grammar

The recommended math level should be 11th grade. This is based on:

Competencies requiring computation:
- Physics principles in Fire Science

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
- Good interpersonal realtions - employability skills
- Current review of study skills, note taking, testing skills, etc.

Date: 10/

DRAFT

HEALTH UNIT COORDINATOR
(VOCATIONAL DIPLOMA)

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s): 10-12th Grade

Related communication competencies:
- Able to communicate with a variety of professional staff verbally and in writing
- Able to transfer written material from one document to another accurately

The recommended math level should be 9th grade. This is based on:

Competencies requiring computation:
- Addition, subtraction, multiplication and, division of numbers with decimal places and some fractions

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

- Basic knowledge of computer keyboards and ability to enter data accurately
- An introductory course in Health Occupations would be useful
- The following attributes would be helpful:
  - Good interpersonal skills
  - Good organizational skills

Date: 10/92

DRAFT

HEALTH UNIT COORDINATOR
(VOCATIONAL DIPLOMA)

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s): 10-12th Grade

Related communication competencies:
- Able to communicate with a variety of professional staff verbally and in writing
- Able to transfer written material from one document to another accurately

The recommended math level should be 9th grade. This is based on:

Competencies requiring computation:
- Addition, subtraction, multiplication and, division of numbers with decimal places and some fractions

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

- Basic knowledge of computer keyboards and ability to enter data accurately
- An introductory course in Health Occupations would be useful
- The following attributes would be helpful:
  - Good interpersonal skills
  - Good organizational skills

Date: 10/92

DRAFT

INDUSTRIAL ENGINEERING TECHNOLOGY
ASSOCIATE DEGREE

The recommended reading level for the above program should be 12th grade. This is based on:

Readability level of textbook(s):
Most are 12th grade (or higher) level technical texts.

Related communication competencies:
Basic oral and written communication skills (technical aspects helpful)

The recommended math level should prepare the student for college-level math and physics. This is based on:

Competencies requiring computation:
- Physics (Tech. Science)
- Tech. Math
- SQA & QC
- Process Planning
- Time & Motion Study

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

- Interpretation of technical drawings
- Basic measurement
- Lab sciences (chemistry, etc.)
- Ability to work with others
- Computer skills (basic)
- Technical writing
- Mechanical and/or electrical understanding
- Problem solving skills

Date: 10/92

DRAFT

INDUSTRIAL ENGINEERING TECHNOLOGY
ASSOCIATE DEGREE

The recommended reading level for the above program should be 12th grade. This is based on:

Readability level of textbook(s):
Most are 12th grade (or higher) level technical texts.

Related communication competencies:
Basic oral and written communication skills (technical aspects helpful)

The recommended math level should prepare the student for college-level math and physics. This is based on:

Competencies requiring computation:
- Physics (Tech. Science)
- Tech. Math
- SQA & QC
- Process Planning
- Time & Motion Study

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

- Interpretation of technical drawings
- Basic measurement
- Lab sciences (chemistry, etc.)
- Ability to work with others
- Computer skills (basic)
- Technical writing
- Mechanical and/or electrical understanding
- Problem solving skills

Date: 10/92

DRAFT

INFORMATION PROCESSING SPECIALIST
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):
  Most at 10th grade level.

Related communication competencies:
  Spelling
  Grammar
  Punctuation
  Interpersonal skills
  Listening skills

The recommended math level should be 9th grade. This is based on:

Competencies requiring computation:
  Basic accounting and recordkeeping
  Hourly logs

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

- Understand and interpret written and oral communication
- Organizational skills
- Flexibility
- Good business ethics

Date: 10/92

DRAFT

INFORMATION PROCESSING SPECIALIST
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):
    Most at 10th grade level.

Related communication competencies:
    Spelling
    Grammar
    Punctuation
    Interpersonal skills
    Listening skills

The recommended math level should be 9th grade. This is based on:

Competencies requiring computation:
    Basic accounting and recordkeeping
    Hourly logs

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

- Understand and interpret written and oral communication
- Organizational skills
- Flexibility
- Good business ethics

Date: 10/92

DRAFT

LEGAL SECRETARY
ASSOCIATE DEGREE

The recommended reading level for the above program should be minimum 10th grade. This is based on:

Readability level of textbook(s):
Most are 11th grade level or higher

Related communication competencies:

1. Understand and interpret written and oral information
2. Listening and interpreting instructions
3. OrganizeS ideas and communicates orally
4. Write messages and compose simple letters
5. Spelling skills
6. Grammar skills
7. Proofreading skills

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
Basic principles of accounting - posting time; calculating bills
Basic computational skills for recordkeeping

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

1. Commitment to goals/need challenge
2. Organizational skills
3. Flexibility - ability to switch gears
4. Teamwork
5. Common sense
6. Level-headed
7. Mature
8. Handles stress well
9. Composition skills
10. Good business ethics and confidentiality skills
11. Leadership skills
12. Responsible and dependable

Date: 10/92

DRAFT

LEGAL SECRETARY
ASSOCIATE DEGREE

The recommended reading level for the above program should be minimum 10th grade. This is based on:

Readability level of textbook(s):
Most are 11th grade level or higher

Related communication competencies:
1. Understand and interpret written and oral information
2. Listening and interpreting instructions
3. OrganizeS ideas and communicates orally
4. Write messages and compose simple letters
5. Spelling skills
6. Grammar skills
7. Proofreading skills

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
Basic principles of accounting - posting time; calculating bills
Basic computational skills for recordkeeping

Other skills, knowledge or attributes that may be helpful in achieving the competencie in this program:

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2. Organizational skills
3. Flexibility - ability to switch gears
4. Teamwork
5. Common sense
6. Level-headed
7. Mature
8. Handles stress well
9. Composition skills
10. Good business ethics and confidentiality skills
11. Leadership skills
12. Responsible and dependable

Date: 10/92

DRAFT

MACHINE MAINTENANCE
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):
- Electrical theory books and publications written by engineers, physicists and electronic technicians
- Math books - higher mathematics level - advanced algebra, trigonometry, etc.

Related machine shop reference books, program communication competencies:
- Receive and give oral communications
- Read, write and follow written rules and regulations
- Work and associate with people at all levels (engineers and architects on the job - home owners has all categories)

The recommended math level should be 10th grade. This is based on:

Related program competencies requiring computation:
- Working knowledge using fractions, decimals, basic algebra
- Ability to use exponents (squares, powers of ten, etc.)
- Trig functions and pythagrean theorem as they apply to alternating current fundamentals and applications in pipe bending

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
- Self motivation
- Physical and manual dexterity
- Knowledge and use of tools
- Knowledge of all other trade areas
- (Electricity involved in practically all aspects)

Date: 10/92

DRAFT

MACHINE MAINTENANCE
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):
- Electrical theory books and publications written by engineers, physicists and electronic technicians
- Math books - higher mathematics level - advanced algebra, trigonometry, etc.

Related machine shop reference books, program communication competencies:
- Receive and give oral communications
- Read, write and follow written rules and regulations
- Work and associate with people at all levels (engineers and architects on the job - home owners has all categories)

The recommended math level should be 10th grade. This is based on:

Related program competencies requiring computation:
- Working knowledge using fractions, decimals, basic algebra
- Ability to use exponents (squares, powers of ten, etc.)
- Trig functions and pythagrean theorem as they apply to alternating current fundamentals and applications in pipe bending

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
- Self motivation
- Physical and manual dexterity
- Knowledge and use of tools
- Knowledge of all other trade areas
- (Electricity involved in practically all aspects)

Date: 10/92

D R A F T

MACHINE TOOL OPERATOR
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 11th grade. This is based on:

Readability level of textbook(s):
- Machine Tool Practices, 4th edition - 11th
- Machinery's Handbook, 24th edition - 11th

Related communication competencies:
- Able to listen effectively
- Ability to communicate in a sensitive (non-offensive) manner
- Can communicate verbally, graphically, or in writing
- Understands the importance of good communications

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
- Be able to use fractions, decimals, and degrees
- Use rectangular and polar coordinates
- Basic algebra (use and rearrange formulas)
- Basic trigonometry/geometry

Other skills, knowledge or attributes that may be helpful in achieving the competencie in this program:

- Practices safety in all activities
- Understands the importance of quality
- Practices good work habits
    1. Attendance/tardiness
    2. Gets along and works with others
    3. Team attitude - values people and their ideas

Date: 10/92

DRAFT

MACHINE TOOL OPERATOR
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 11th grade. This is based on:

Readability level of textbook(s):
- Machine Tool Practices, 4th edition - 11th
- Machinery's Handbook, 24th edition - 11th

Related communication competencies:
- Able to listen effectively
- Ability to communicate in a sensitive (non-offensive) manner
- Can communicate verbally, graphically, or in writing
- Understands the importance of good communications

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
- Be able to use fractions, decimals, and degrees
- Use rectangular and polar coordinates
- Basic algebra (use and rearrange formulas)
- Basic trigonometry/geometry

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- Understands the importance of quality
- Practices good work habits
  1. Attendance/tardiness
  2. Gets along and works with others
  3. Team attitude - values people and their ideas

Date: 10/92

DRAFT

MARKETING
ASSOCIATE DEGREE

The recommended reading level for the above program should be 11th grade. This is based on:

Readability of textbook(s): 11th - 12th

Related communication competencies:
- Interpersonal communications/teamwork
- Customer relations skills
- Telephone communications
- Computer communications
- Reading comprehensive
- Analyze and assimilate written material
- Organize information
- Communicate information

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
- Solving for unknowns
- 6-month merchandise plan
- Markup, markdown
- Computation of margins
- Budgeting

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program.

- Computer skills
- Human relations skills
- Assertiveness
- Maturity
- Good business ethics
- Ability to listen
- Business environment awareness

Date: 10/92

DRAFT

MARKETING
ASSOCIATE DEGREE

The recommended reading level for the above program should be 11th grade. This is based on:

Readability of textbook(s): 11th - 12th

Related communication competencies:
- Interpersonal communications/teamwork
- Customer relations skills
- Telephone communications
- Computer communications
- Reading comprehensive
- Analyze and assimilate written material
- Organize information
- Communicate information

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
- Solving for unknowns
- 6-month merchandise plan
- Markup, markdown
- Computation of margins
- Budgeting

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program.

- Computer skills
- Human relations skills
- Assertiveness
- Maturity
- Good business ethics
- Ability to listen
- Business environment awareness

Date: 10/92

MECHANICAL DESIGN
ASSOCIATE DEGREE

[The following is submitted for the ease of, but not demanded for, successful program completion.]

The recommended reading level for the above program should be 12th grade. This is based on: Readability test of highest level text and reference materials.

Readability level of textbook(s):
- Technical specifications
- Reference manuals and engineering standards
- Supply catalog information

*Technical references read at 17+ level

Related communication competencies:
- Verbal skills at organized direction of specific technical material
- Ability to functionally communicate with others in any format

The recommended math level should be 11th grade. This is based on:

Competencies requiring computation:
- Formula translation
- Calculation of area volume of basic geometric shapes
- Measurement unit conversion
- Roots and powers
- Scientific notation
- Ratio and proportion
- Fractional and decimal relation
- Computation manipulation
- Function and relate to fractional inch, decimal inch, and metric values
- Cartesian and polar coordinate function
- Trig awareness and practical function
- Algebraic formula manipulation
- Calculator function
- Math competency by understanding
- Geometry vocabulary

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
- Problem analysis
- Solution awareness and affect
- Applied physics basics
- Material composition and workability (i.e., chemistry, manufacturing)
- Spatial relationship
- Applied math ability
- Variable unit measurement ability with conversion
- Specific drafting competencies
- Ability to work collectively with others of varying skills and aptitude to an effective objective

Date: 10/92

DRAFT

MECHANICAL DESIGN
ASSOCIATE DEGREE

[The following is submitted for the ease of, but not demanded for, successful program completion.]

The recommended reading level for the above program should be 12th grade. This is based on: Readability test of highest level text and reference materials.

Readability level of textbook(s):
- Technical specifications
- Reference manuals and engineering standards
- Supply catalog information

*Technical references read at 17+ level

Related communication competencies:
- Verbal skills at organized direction of specific technical material
- Ability to functionally communicate with others in any format

The recommended math level should be 11th grade. This is based on:

Competencies requiring computation:
- Formula translation
- Calculation of area volume of basic geometric shapes
- Measurement unit conversion
- Roots and powers
- Scientific notation
- Ratio and proportion
- Fractional and decimal relation
- Computation manipulation
- Function and relate to fractional inch, decimal inch, and metric values
- Cartesian and polar coordinate function
- Trig awareness and practical function
- Algebraic formula manipulation
- Calculator function
- Math competency by understanding
- Geometry vocabulary

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
- Problem analysis
- Solution awareness and affect
- Applied physics basics
- Material composition and workability (i.e., chemistry, manufacturing)
- Spatial relationship
- Applied math ability
- Variable unit measurement ability with conversion
- Specific drafting competencies
- Ability to work collectively with others of varying skills and aptitude to an effective objective

Date: 10/9

DRAFT

MEDICAL ASSISTANT
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):
    Varied levels from 10-17

Related communication competencies:
    Ability to follow written instructions
    Ability to write clear, concise information/instructions
    Ability to communicate orally and in writing using proper grammar

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
    Medical Skills I & II competencies dealing with: vital signs, medications, examinations, etc. (decimals, fractions and percents)
    Medical insurance competencies dealing with patient and third party payor and provider write-offs
    Medical Laboratory I & II competencies dealing with solutions, lab results, etc.

Other skills, knowledge or attributes that may be helpful in achieving the competencie in this program:

    Good interpersonal relations - employability skills
    Current review of study skills, note taking, test taking skills, etc.
    Keyboarding and/or beginning computer experience

Date: 10/92

DRAFT

MEDICAL ASSISTANT
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):
    Varied levels from 10-17

Related communication competencies:
    Ability to follow written instructions
    Ability to write clear, concise information/instructions
    Ability to communicate orally and in writing using proper grammar

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
    Medical Skills I & II competencies dealing with: vital signs, medications, examinations, etc. (decimals, fractions and percents)
    Medical insurance competencies dealing with patient and third party payor and provider write-offs
    Medical Laboratory I & II competencies dealing with solutions, lab results, etc.

Other skills, knowledge or attributes that may be helpful in achieving the competenci in this program:

Good interpersonal relations - employability skills
Current review of study skills, note taking, test taking skills, etc.
Keyboarding and/or beginning computer experience

Date: 10/92

DRAFT

MEDICAL OFFICE SPECIALIST
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade (estimated). This is based on:

Readability level of textbook(s):
I will have to check for sure

Related communication competencies:
- Spell
- Punctuate
- Grammar
- Composition
- Proofreading
- Proper spoken English usage
- Understand & interpret oral and written instructions

The recommended math level should be 9th grade. This is based on:

Competencies requiring computation:
Basic computational ability for adding columns across and down

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

- Commitment to goal
- Organizational
- Flexibility
- Teamwork
- Mature
- Level headed
- Confidentiality and ethics
- Integrity

Date: 10/92

DRAFT

MEDICAL OFFICE SPECIALIST
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade (estimated). This is based on:

Readability level of textbook(s):
- I will have to check for sure

Related communication competencies:
- Spell
- Punctuate
- Grammar
- Composition
- Proofreading
- Proper spoken English usage
- Understand & interpret oral and written instructions

The recommended math level should be 9th grade. This is based on:

Competencies requiring computation:
- Basic computational ability for adding columns across and down

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

- Commitment to goal
- Organizational
- Flexibility
- Teamwork
- Mature
- Level headed
- Confidentiality and ethics
- Integrity

Date: 10/92

DRAFT

NURSING
ASSOCIATE DEGREE

The recommended reading level for the above program should be 12th grade. This is based on:

Readability level of textbook(s): Texts are 10th to 14th

Related communication competencies:
1) Read and understand general nursing journals at 10-12+;
2) individual and group oral communication @ (10-12);
3) Use of correct grammar and spelling.
4) Construct a paragraph with complete sentences

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation: Medication administration calculation, 1 variable equations, story-problem solving).

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

1. Eye-hand coordination to accomplish fine motor skills
2. Sensory abilities to assess patients
3. Problem solving/critical thinking
4. Ability to cope with stressful stiatuions effectively
5. Takes responsibility for own actions, including punctuality, regular attendance and completes assignments

Date: 10/92

DRAFT

NURSING
ASSOCIATE DEGREE

The recommended reading level for the above program should be 12th grade. This is based on:

Readability level of textbook(s): Texts are 10th to 14th

Related communication competencies:
1) Read and understand general nursing journals at 10-12+;
2) individual and group oral communication @ (10-12);
3) Use of correct grammar and spelling.
4) Construct a paragraph with complete sentences

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation: Medication administration calculation, 1 variable equations, story-problem solving).

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

1. Eye-hand coordination to accomplish fine motor skills
2. Sensory abilities to assess patients
3. Problem solving/critical thinking
4. Ability to cope with stressful stiatuions effectively
5. Takes responsibility for own actions, including punctuality, regular attendance and completes assignments

Date: 10/92

DRAFT

OFFICE ASSISTANT
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):

Related communication competencies:
- Interpersonal skills - ability to work with others
- Written grammar, spelling, punctuation
- Listening and interpreting directions
- Proper English usage in oral communications
- Legible handwriting

The recommended math level should be 9th grade. This is based on:

Competencies requiring computation:
- Basic arithmetic for recordkeeping, business math, and typing

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
- Follow directions - understand and interpret written and oral info
- Commitment to importance of work (punctuality, attendance, work ethic, attitude, business ethics, dependability, maturity)
- Organizational skills
- Flexibility, ability to change, ability to work under pressure
- Composition
- Keyboarding
- Computer literacy
- Proofreading and editing
- Attention to detail

Date: 10/92

DRAFT

OFFICE ASSISTANT
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):

Related communication competencies:
- Interpersonal skills - ability to work with others
- Written grammar, spelling, punctuation
- Listening and interpreting directions
- Proper English usage in oral communications
- Legible handwriting

The recommended math level should be 9th grade. This is based on:

Competencies requiring computation:
- Basic arithmetic for recordkeeping, business math, and typing

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
- Follow directions - understand and interpret written and oral info
- Commitment to importance of work (punctuality, attendance, work ethic, attitude, business ethics, dependability, maturity)
- Organizational skills
- Flexibility, ability to change, ability to work under pressure
- Composition
- Keyboarding
- Computer literacy
- Proofreading and editing
- Attention to detail

Date: 10/92

D R A F T

PHYSICAL THERAPIST ASSISTANT
ASSOCIATE DEGREE

The recommended reading level for the above program should be 12th grade. This is based on:

Readability level of textbook(s): 12 + (some as high as 17th grade level)

Related communication competencies:
- Ability to read and understand physician's orders, medical charts, therapist treatment plans, etc.
- Ability to write clear, concise, and accurate progress summaries to communicate with health care team.

The recommended math level should be 12th grade. This is based on:

Competencies requiring computation:
- Measuring limb length and girth.
- Determination of traction amounts and angles.
- Measuring joint range of motion with goniometer.
- Application of basic principles of physics:
  - motion
  - forces
  - wavelengths
  - electricity
  - energy

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

1. Good manual skills and coordination.
2. Good physical condition.
3. Ability to problem solve.
4. Good interpersonal skills
5. Responsible and dependable.
6. Critical thinker.
7. Ability to make good decisions.

Date: 10/92

DRAFT

PHYSICAL THERAPIST ASSISTANT
ASSOCIATE DEGREE

The recommended reading level for the above program should be 12th grade. This is based on:

Readability level of textbook(s): 12 + (some as high as 17th grade level)

Related communication competencies:
- Ability to read and understand physician's orders, medical charts, therapist treatment plans, etc.
- Ability to write clear, concise, and accurate progress summaries to communicate with health care team.

The recommended math level should be 12th grade. This is based on:

Competencies requiring computation:
- Measuring limb length and girth.
- Determination of traction amounts and angles.
- Measuring joint range of motion with goniometer.
- Application of basic principles of physics:
  - motion
  - forces
  - wavelengths
  - electricity
  - energy

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

1. Good manual skills and coordination.
2. Good physical condition.
3. Ability to problem solve.
4. Good interpersonal skills
5. Responsible and dependable.
6. Critical thinker.
7. Ability to make good decisions.

Date: 10/92

DRAFT

POLICE SCIENCE
ASSOCIATE DEGREE

The recommended reading level for the above program should be 12th grade. This is based on:

Readability level of textbook(s):
- College level texts
- Legal updates and refers 16+

Related communication competencies:
- Report writing
- Interview
- Testifying in court

The recommended math level should be 10th grade. This is based on:
- Algebra/geometry

Competencies requiring computation:
- Apply formulas using a variable
- Algebra
- Ratios
- Traffic accident investigations

Other skills, knowledge or attributes that may be helpful in achieving the competencie in this program:
- Good eye to hand coordination
- Assessment of body language
- Able to make independent judgement and function without supervision
- Good problem solving

Date: 10/92

DRAFT

POLICE SCIENCE
ASSOCIATE DEGREE

The recommended reading level for the above program should be 12th grade. This is based on:

Readability level of textbook(s):
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- Apply formulas using a variable
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- Good eye to hand coordination
- Assessment of body language
- Able to make independent judgement and function without supervision
- Good problem solving

Date: 10/92

DRAFT

SUPERVISORS' MANAGEMENT
ASSOCIATE DEGREE

The recommended reading level for the above program should be 11th grade. This is based on:

Readability level of textbook(s):

Related communication competencies:
- Written
- Oral
- Ability to problem solve and decisionmaking

The recommended math level should be 11th grade. This is based on:

Competencies requiring computation:
- Basic Math
- Algebra (preferred)

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

- Computer skills
- Human relations skills
- Assertiveness
- Maturity
- Good business ethics
- Ability to listen

Date: 10/92

DRAFT

SUPERVISORS' MANAGEMENT
ASSOCIATE DEGREE

The recommended reading level for the above program should be 11th grade. This is based on:

Readability level of textbook(s):

Related communication competencies:
- Written
- Oral
- Ability to problem solve and decisionmaking

The recommended math level should be 11th grade. This is based on:

Competencies requiring computation:
- Basic Math
- Algebra (preferred)

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

- Computer skills
- Human relations skills
- Assertiveness
- Maturity
- Good business ethics
- Ability to listen

Date: 10/92

DRAFT

WELDING
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 12th grade. This is based on:

Readability level of textbook(s): 10th grade
Charts (Interp.)
Service Manuals
Tech. Manuals
Ref. Manuals

Related communication competencies:

1. Writing resume and cover letters
2. Writing letters: ordering parts, returning parts, thank you's, requesting donations, setting up meeting date and time for tour of employer plant
3. Answering telephone and taking messages
4. Procedures, steps of...(logical thinking & demon. the skill)
5. Public relations
6. Follow written directions
7. Prob. solving skills
8. Key board skills
9. Penmanship
11. Job interviews

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
Measuring & layout tools
Conversions (fractions, decimals and metric)
Metal fab layout: geometric construction
Welding inspection (visual inspection testing)
Machine amperage and volt settings
Practical physics, basic metallurgy, practical strength of materials

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
Terminology of welding field
Appearance, professional (welder)
Safety hazard materials, etc.
Self motivation
Getting along w/fellow employee
Task completion (dead lines)
Showing up for work (if not - calling in - telephone usage...)
Accepting criticism (positively)
Positive attitude toward working with multi-cultural groups, etc.
Follow instructions

Date: 10/92

DRAFT

WELDING
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 12th grade. This is based on:

Readability level of textbook(s): 10th grade
- Charts (Interp.)
- Service Manuals
- Tech. Manuals
- Ref. Manuals

Related communication competencies:

1. Writing resume and cover letters
2. Writing letters: ordering parts, returning parts, thank you's, requesting donations, setting up meeting date and time for tour of employer plant
3. Answering telephone and taking messages
4. Procedures, steps of...(logical thinking & demon. the skill)
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- Practical physics, basic metallurgy, practical strength of materials

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
- Terminology of welding field
- Appearance, professional (welder)
- Safety hazard materials, etc.
- Self motivation
- Getting along w/fellow employee
- Task completion (dead lines)
- Showing up for work (if not - calling in - telephone usage...)
- Accepting criticism (positively)
- Positive attitude toward working with multi-cultural groups, etc.
- Follow instructions

Date: 10/9

DRAFT

FOOD SCIENCE TECHNICIAN
ASSOCIATE DEGREE

The recommended reading level for the above program should be 12th grade. This is based on:

Readability level of textbook(s): College level
- USDA regulations
- Equipment manuals
- Association of official analytical chemists lab manual
- Standard methods for the examination of dairy products
- American Association of Cereal Chemists Lab Manual

Related communication competencies:
- Form sentences
- Form paragraphs
- Write technical reports using logical, sequential thinking skills
- Follow instructions
- Problem solve
- Spelling

The recommended math level should be 9th grade. This is based on:

Competencies requiring computation:
- Manipulate formulas
- Percents
- Ratios
- Metric conversions
- Division
- Subtraction
- Addition
- Multiplication
- Problem solving/deductive reasoning

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
- Manual dexterity
- Personal hygiene/appearance
- Regular attendance/punctuality
- Self starter and team worker
- Listening skills
- Time management
- Follow instructions

Date: 10/92

DRAFT

FOOD SCIENCE TECHNICIAN
ASSOCIATE DEGREE

The recommended reading level for the above program should be 12th grade. This is based on:

Readability level of textbook(s): College level
- USDA regulations
- Equipment manuals
- Association of official analytical chemists lab manual
- Standard methods for the examination of dairy products
- American Association of Cereal Chemists Lab Manual

Related communication competencies:
- Form sentences
- Form paragraphs
- Write technical reports using logical, sequential thinking skills
- Follow instructions
- Problem solve
- Spelling

The recommended math level should be 9th grade. This is based on:

Competencies requiring computation:
- Manipulate formulas
- Percents
- Ratios
- Metric conversions
- Division
- Subtraction
- Addition
- Multiplication
- Problem solving/deductive reasoning

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
- Manual dexterity
- Personal hygiene/appearance
- Regular attendance/punctuality
- Self starter and team worker
- Listening skills
- Time management
- Follow instructions

Date: 10/92

DRAFT

OFFICE MACHINE REPAIR
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 8th-12th grade. This is based on:

Readability level of textbook(s):
- Electric typewriter service manual (8th grade)
- Copies/fax service manual (12th grade)

Related communication competencies:
- People skills - treating people like customers
    1. Speaking skills
    2. Written orders
- Writing skills
    1. Service tickets
    2. Parts ordering

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
- Billing/ordering

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
- Mechanics
- Electricity/Electronics
- Self starter
- Possess manners
- Personal hygiene
- Trouble shooting
- Dress code
- Manual dexterity
- Hand-eye coordination
- Able to stay on a time schedule

Date: 10/92

DRAFT

OFFICE MACHINE REPAIR
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 8th-12th grade. This is based on:

Readability level of textbook(s):
  Electric typewriter service manual (8th grade)
  Copies/fax service manual (12th grade)

Related communication competencies:
  People skills - treating people like customers
    1. Speaking skills
    2. Written orders
  Writing skills
    1. Service tickets
    2. Parts ordering

The recommended math level should be 10th grade. This is based on:

Competencies requiring computation:
  Billing/ordering

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:

- Mechanics
- Electricity/Electronics
- Self starter
- Possess manners
- Personal hygiene
- Trouble shooting
- Dress code
- Manual dexterity
- Hand-eye coordination
- Able to stay on a time schedule

Date: 10/92

DRAFT

NURSING ASSISTANT
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):
Being a Nursing Assistant, 6th edition (10th grade)

Related communication competencies:
Reading and following directions of procedures
Reporting and recording of observations onto charts

The recommended math level should be 8th grade. This is based on:

Competencies requiring computation:
Intake and output converting from ounces to cc's. (i.e. 3/4 carton (1/2 pint container) of milk into cc's. 1/2 can 7-up into cc's.)

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
Measuring temperature, pulse, respirations and blood pressure
Observing skin discolorations (i.e., jaundice, pallor, erythema, cyanosis)
Lifting, moving, and transferring patients

Date: 10/9

DRAFT

NURSING ASSISTANT
VOCATIONAL DIPLOMA

The recommended reading level for the above program should be 10th grade. This is based on:

Readability level of textbook(s):
Being a Nursing Assistant, 6th edition (10th grade)

Related communication competencies:
Reading and following directions of procedures
Reporting and recording of observations onto charts

The recommended math level should be 8th grade. This is based on:

Competencies requiring computation:
Intake and output converting from ounces to cc's. (i.e. 3/4 carton (1/2 pint container) of milk into cc's. 1/2 can 7-up into cc's.)

Other skills, knowledge or attributes that may be helpful in achieving the competencies in this program:
Measuring temperature, pulse, respirations and blood pressure
Observing skin discolorations (i.e., jaundice, pallor, erythema, cyanosis)
Lifting, moving, and transferring patients

Date: 10/5.

TECH-PREP
CURRICULUM COMPETENCY MAP
COMMUNICATION SKILLS

All programs at Blackhawk Technical College require courses and/or competency in oral and written English language skills. The following are minimum competencies identified by BTC faculty to succeed in the Communications Skills courses at BTC:

Entry Level Competencies

1. Demonstrate Library Skills by locating information using reader's guide, computers, card catalog, stacks, microfiche and reference books
2. Document/cite sources correctly using bibliography, footnotes, note taking and paraphrasing
3. Apply the 5 commonly used spelling rules
4. Correctly use: parts of speech, plurals, possessives and verbs
5. Construct sentences with agreement between subject and verb, pronouns and nouns, adverbs, adjectives, prepositions and conjunctions
6. Correctly use: commas, semicolons, colon, quotation marks and apostrophe
7. Apply basic capitalization rules
8. Apply basic rules of abbreviation
9. Use appropriate sequential writing process (brainstorm, pre-write, draft, revise, edit, re-write)
10. Construct paragraphs using topic sentences and appropriate transitions
11. Write a short essay using:
    a. Introduction
    b. Support
    c. Conclusion
12. Write a well organized outline
13. Compose a business letter using appropriate format
14. Apply the following study skills to class assignments: skimming, taking notes, taking tests, following directions, managing time and finding information
15. Use word processor for written assignments

High School

High School Course(s) Covering Above Competencies	Competencies (# from above) Covered In Each High School Course
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	

Math Curriculum

SYLLABUS

WEEK 1

Day 1:

- Introductions
- Overview of Quality Assurance
- Stem-and-leaf plots
  - Mystery Data
  - Oscar Winners
  - Ages of Presidents

Day 2:

- Video: Using Statistics
- Measures of Central Tendency (Mean, Median, Mode)
  - Tiddly Wink Snap
  - 50 M backwards run
  - Student in the Middle
  - What do you think?

Day 3:

- Measures of Variability (Range, Standard Deviation)
- Normal Curve
- Activity 2: Reaction Times
- Using calculator to find means and standard deviations

Day 4:

- Activity 1: Pouring Water into unmarked cups
- Review of mean, median, mode, standard deviation, range
- Wrap-up / Summary

WEEK 2

Day 1:

- Tour of airport and aviation center

Day 2:

- Definitions of triangle and right triangles
- Video, Unit 21 Using Right Triangle Relationships
- Pythagorean Theorem
- Activity 2: Calculating diagonal lengths of rectangles

Day 3:

- Trig Ratios
- Use calculators to find trig ratios
- Solve triangles using trig ratios
- What do they call a big grass field?
- Daffynition Decoder

Day 4:

Activity 3: Calculating the length of the school building
Making and using a hypsometer

WEEK 3

Day 1:

Percent
Exercises
Activity 3 - Popcorn

Day 2:

Video: Measuring in English and Metric
Units conversion

Day 3:

Activity 2: Measure Volume
Activity 3: Measure Area

Day 4:

Scientific notation
Using a calculator with scientific notation
Exercises
Video: Using Scientific Notation (?)

WEEK 4

Day 1:

The rectangular coordinate system
Tuba factory
Supplementary Worksheet 1
Floor scale drawing

Day 2:

Incremental coordinate system
Supplementary Worksheet 2
Picture draw & share

Day 3:

Video: Using Trig Functions
Activity 1: Unit Circle
Introduction to Sine waves

Day 4:

Exploring Sine Waves with Graphing Calculators
Wrap-Up
Evaluation

APPLIED MATH

WEEK ONE

QUALITY ASSURANCE AND PROCESS CONTROL

Introduction

Since the early '80s, a revolution has been going on in this country. It is a revolution about *quality*. Consumers are increasing their demands for quality products and competitors are trying to provide more quality. Many companies in the U.S. and abroad are trying to provide high quality products and services in a struggle to hold on to a "piece" of the market. Managers and employees of large corporations are finding their way back to schools to obtain academic training in quality. Every day, thousands of people fly across the country to talk and learn about quality. In many companies, certain employees are assigned to jobs where all they do is think, write, and teach quality. On the other hand, some companies are losing business and laying off people because they have ignored quality.

Quality assurance and process control--or as it is sometimes called--*statistical process control* (SPC), is a tool we use to understand and monitor quality.

Unit Objectives

In this unit we will learn how to:

- -collect data
- -construct stem and leaf plots and histograms
- -find the measures of central tendency (mean, median, mode)
- -find measure of dispersion or variability (range, standard deviation)
- -use the measures of central tendency and variability to describe data shown on bell-shaped curves

THE NEED FOR QUALITY ASSURANCE AND PROCESS CONTROL

Let's begin by looking back at how quality control got started in our country—and elsewhere. Then we'll try to distinguish between a *product* and a *process*, and learn what's meant by a *process chart*. As we do all of this, we'll try to develop a good sense of what quality is all about.

A little background

American industry is at the start of a *new industrial revolution*— a revolution where the roles of management, labor, and machines are being redefined. Barring a world event of the magnitude of World War II, American industry may not again experience the competitive monopoly it enjoyed in the late 1940s and early 1950s. The U.S. is now in a world economy, and competitively we have not been doing too well in the last three decades. Perhaps it's because we are still organized the way we were a century ago. Except for a few enlightened organizations, we are not responding to the demands of our time the way the Japanese and other industrial societies are.

Why have U. S. companies not updated themselves? Probably because these old techniques worked so well for them in the past, they thought they had no reason to change. The older techniques appeared to work well during the first industrial revolution, and also during the period after World War II. The U.S. was in the "driver's seat," and everything seemed to be working fine. Today, American industry is primarily modeled after the methods of Frederick Winslow Taylor (1856-1915). In the *Taylor model*, management does all the thinking, planning, and problem solving—and labor does all the production work.

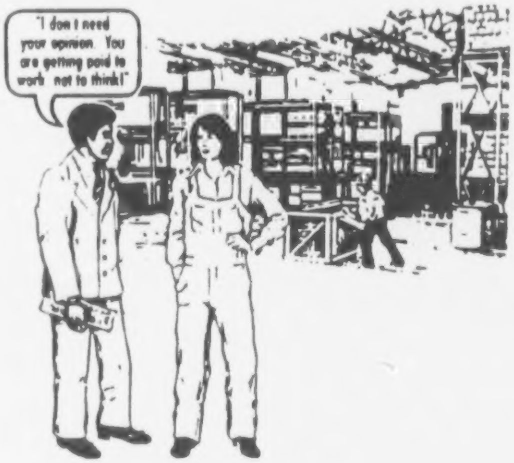

"I don't need your opinion. You are getting paid to work not to think!"

Figure 32-3
The "spirit" of the Taylor model

Why did the *Taylor model*—the separation of planning and production functions—work so well in the past? And why has it failed us in recent years? Certainly, production was simpler in Taylor's time. Engineers and managers had mastered the process well enough to do all the planning and problem solving. Production processes were mostly a series of repetitive, simple-minded tasks. A relatively unskilled and low-paid labor force could handle them. So factories were able to produce high volumes of output with vast numbers of unskilled production workers. *Quality was of relatively low concern.* With labor, material, and energy cheap and plentiful, companies could tolerate waste. They could compete simply by producing in abundance, then separating the good products from the bad.

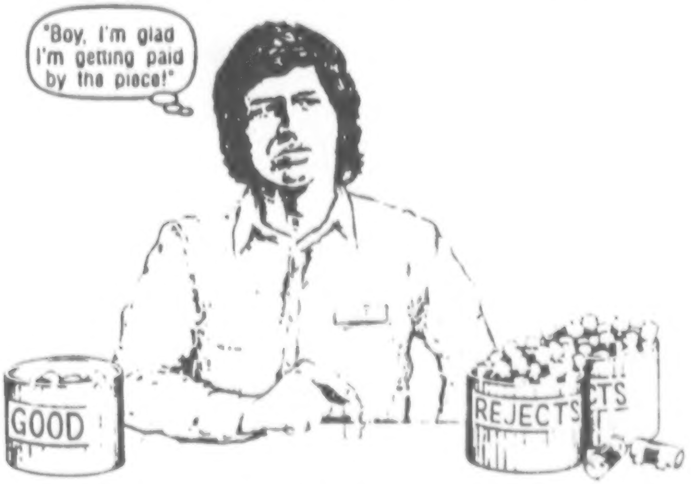

"Boy, I'm glad I'm getting paid by the piece!"
GOOD
REJECTS
TS

Figure 32-4
Separating out the good from the bad

During the 1940s and 1950s, when consumer demand was high, American industry still had little incentive to be concerned about quality issues. But other nations, particularly Japan, wanted to penetrate the world market. They became very interested in quality and productivity. They embraced the model of Dr. W. Edwards Deming, an American statistician and management consultant.

The *Deming model* features improvement of an industry's productivity and competitive position through *quality of product* and *avoidance of waste*. This means that quality must be designed into every process (*do it right the first time*) rather than relying on product inspection after the fact, followed by separation of good parts from bad. This emphasis requires a careful training of personnel so that there are highly skilled workers at all levels. This also means getting all employees involved in planning and problem solving—that is, participatory management.

Many enlightened leaders of American industry have already seen the need for adopting the *Deming model.* They see the need for this new model if we are to catch up and remain competitive in this new atmosphere. They see production processes becoming more complex. Management and engineering personnel are no longer in a position to make all the planning and problem-solving decisions alone. They need the help of production workers—of everybody involved in the manufacturing of the product. Only by working together as a group can a company understand the *whole process* and ensure the final product's quality.

We need such a change in our industrial culture. We need an evolution in management attitudes that *moves us from the Taylor model to the Deming model.* We also need workers who are trained to work in this new environment. These workers need skills in group problem solving, in collecting and handling data, in understanding and communicating in statistical terms, and in participatory management.

This is the primary reason that these two units in Quality Assurance and Process Control have been created. Their main objectives are to provide you, the work force of tomorrow, with the mathematical skills to meet the challenges of the **new** industrial revolution.

The concept of quality

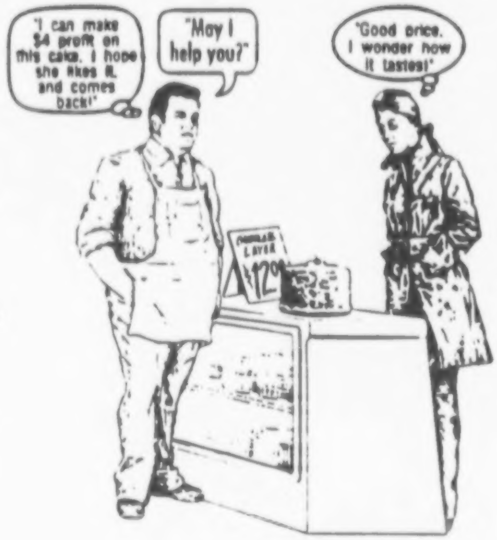

"I can make $4 profit on this cake. I hope she likes it and comes back!"
"May I help you?"
"Good price. I wonder how it tastes!"
LAYER

Figure 32-7
Different viewpoints

A process is characterized by the one who makes the product (called the *producer*) and also by the one who uses the product (called the *consumer*). Producers and consumers may view products and quality in somewhat **different ways**. To the consumer "quality" is important. Does the product do what the consumer wants it to do? Is it safe enough? Is it reasonably priced? Is it reliable?

To the *producer*, both quality of product and process are important. Does the product comply with standards? Will the consumer choose it, given other choices? Is it profitable? Usually a "good" producer will view a product from a consumer's perspective, and will produce a "good quality product" as viewed by consumers.

Case studies have shown that when a business responds to customer requirements, the company develops a reputation for quality. For example, IBM has a reputation for good service. Walt Disney has a reputation for courtesy and assistance. Caterpillar Company, a manufacturing giant of heavy industrial equipment, has a reputation for reliability. But what is quality? Many will say that it is easier to recognize quality in a product than it is to define it.

Experts on quality control in industry— such as Joseph Juran[1] and Philip Crosby[2]—have assisted many companies, both here and abroad, with an understanding of what *quality* is, and how to achieve it.

---

[1] Joseph Juran. Renowned international consultant in quality control. Member of a group of engineers that assisted the Western Electric Inspection Department. Developed many concepts in quality. His work is credited as being the basis of Japan's postwar management.

[2] Philip Crosby. Founded Quality College, Winter Park, Florida. Developed the "14-Step Quality Improvement Program." Author of many publications on quality-related topics, such as "Quality is Free" and "Zero Defects."

Here's what international experts like Juran and Crosby say about *quality*:

- *Quality* is a *match to the intended use.* That is, a quality product must perform the way it was intended to perform.
- *Quality* is a *conformance to requirements.* That is, a quality product meets the requirements imposed by the customer.
- *Quality* makes the product a *natural choice for the customer.* That is, the customer—given other choices—always chooses that particular product without much hesitation.

Consumer surveys have shown that a customer usually prefers one product over another because of a combination of the following.

attractiveness—How does it look?

reliability—Will it work when the customer needs it?

serviceability—Is it easy to repair?

price—Is it comparable to similar products?

convenience—Is it easy to use?

cost effectiveness—Is it fairly inexpensive to use?

But, do the customers know what they want? Quality is more than what customers ask for. Sometimes a customer would like some features but doesn't specify them. Or sometimes a customer is unaware of new breakthroughs that enhance quality.

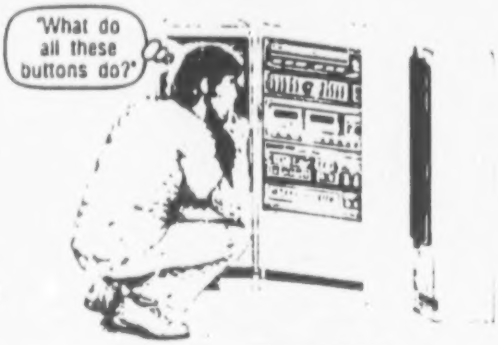

"What do all these buttons do?"

Figure 32-8
Making the product too complicated?

Study Activity:

1. You probably know about—or have heard of—some companies that have reputations as quality leaders. Identify three such companies. State the reasons that you think they have achieved that reputation.
2. List four characteristics in a car that are important to you.
3. List four characteristics of quality service/product you expect to find in a fast-food restaurant.

WORKING WITH DATA

Before we begin to analyze data distributions and learn how to use them to control quality, let's review some of the ways we collect and organize data.

Data simply means *information*. And although data by itself may not be useful, what you do with it can be very important. In a *Quality Assurance Program* we collect, organize, and interpret data in order to understand and regulate the process. Although data collection can be done in a variety of ways, we work with two major methods—*counting* and *measuring*.

Data by counting

Counting is one of the first basic skills we learn as children. Counting is performed in order to get a sense of quantity—*how much, how big, how long*, and *how soon*. The numbers we use for counting are the familiar *natural numbers*: 1, 2, 3, 4, 5, 6, 7, and so on. In Quality Assurance (QA) and Process Control (PC) programs, we use counting primarily to record defective (unacceptable) items. The data we get by counting is referred to as *attribute data*.

Example 2: ***Calculating percent of defective items in a sample***

Consider a newspaper printing company that produces 1000 newspapers in 20 minutes of production. After inspection of these 1000 papers, defects are noted and recorded as shown below. For now, assume that there is only one type of defect in each paper.

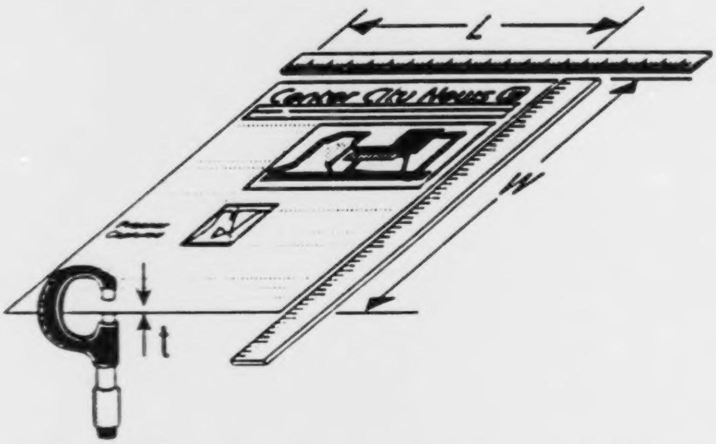
	Type of defect	Number of defective papers
1.	Ink stains on front page	50
2.	Print is too light	80
3.	Some lines are slanted	30
	Total newspapers with defects	160

Note that the average number of defects per item (u) in the sample (n) and the entire population (N) all result from counting. The type of data that can be obtained by simple counting is called *attribute data*.

Attribute data helps us classify an item as conforming (good) or nonconforming (bad). In a later section, we will deal with attribute data in more detail. What about those items that are not defective? Are they all the same? Suppose we look at two of those newspapers produced. At first glance they will appear to be alike. But a closer look—involving *measurements*—may reveal many differences.

Data by measuring

In the previous section we saw examples where groups of items—involving newspapers and calculators—were inspected. The only skill needed to accumulate data was an ability to count. However, what if one had to record the thickness, or the length and width of the front page for each newspaper produced?



We know that it is impossible to produce two items that are identical. This difference from item to item in production is called *variation*[3]. It can be observed only by recording measurements of the item. To do that, you must know how to measure with a variety of instruments—rulers, calipers, micrometers, etc.—rather than just knowing how to count. The data collected as the result of *measuring* is called *variable data*. All variable data is in numerical form. For example, let's consider our example of newspaper production. The table that follows shows the paper thicknesses from a sample of 30 newspapers ($n = 30$).

---

[3] We will deal with the concept of variation again, in this unit, and also in Unit 33 when we talk about control charts.

Example 4:
Data by measurement for newspaper production

Table 1: Thickness of a newspaper sheet

Sample No. (newspaper)	Thickness (inch)	Sample No. (newspaper)	Thickness (inch)
1	0.0042	16	0.0036
2	0.0040	17	0.0041
3	0.0039	18	0.0038
4	0.0043	19	0.0041
5	0.0040	20	0.0042
6	0.0041	21	0.0040
7	0.0040	22	0.0037
8	0.0043	23	0.0040
9	0.0035	24	0.0038
10	0.0039	25	0.0043
11	0.0040	26	0.0041
12	0.0041	27	0.0045
13	0.0039	28	0.0040
14	0.0039	29	0.0037
15	0.0040	30	0.0039

Organizing data for presentation

After data has been collected it should be organized by making a tally, a table, or a graph.

Tally

When you make a *tally*, first make a list of convenient increments, called *cells*. The measurements in Table 1 vary from a low of 0.0035 inch to a high of 0.0045 inch. With an increment of 0.0001 inch, you can make a list of eleven cells from 0.0035 inch, to 0.0045 inch. Then, for each sample measurement, place a *tic mark* beside the matching cell in your list. The count of tic marks in each cell gives a list of *frequencies*, as shown below.

Measurement (in.)	"Tic" count	Frequency
0.0035	|	1
0.0036	|	1
0.0037	| |	2
0.0038	| |	2
0.0039	| | | | |	5
0.0040	| | | | | | | |	8
0.0041	| | | | |	5
0.0042	| |	2
0.0043	| | |	3
0.0044		0
0.0045	|	1
Total of frequencies:		30

Note the following:

- The measurement of 0.0044 inch does not occur and so has a frequency of zero.
- The sum of the frequencies (Σf) is equal to the sample size (n). In this example, $\Sigma f = n = 30$.

Histogram

Also, as you have seen before, one can construct a *histogram* from a tally. Figure 32-9 shows this. Given the data of the previous example, you can produce the following histogram with *frequency* along the *vertical axis* and *thickness* along the *horizontal axis.*

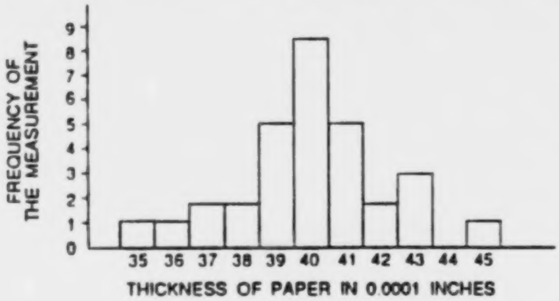


Figure 32-9
Histogram of thickness measurements

Histograms may be used to construct a *frequency distribution curve.* Figure 32-10 shows a distribution curve produced from our sample data. A bell curve is drawn "over" the histogram[5].

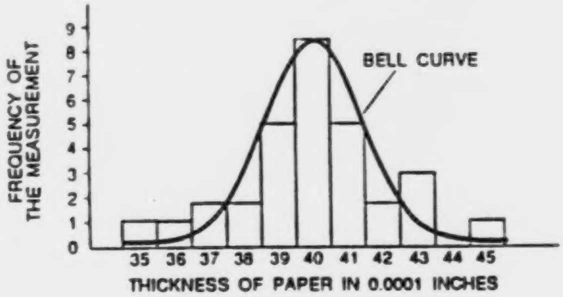


Figure 32-10
Distribution curve

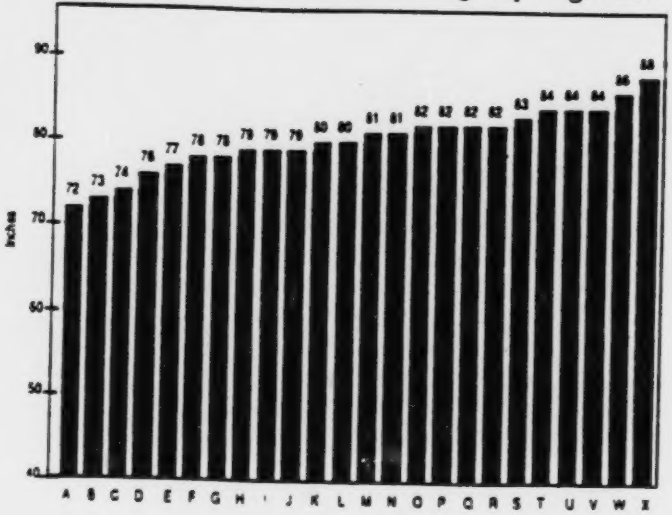
---

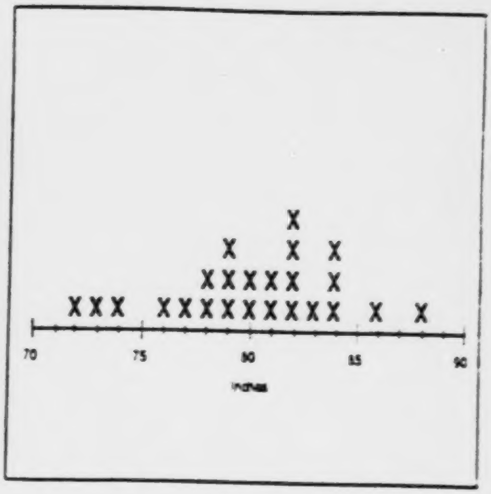
[5] By using the *mean value* and *standard deviation* for your data, you can create a "bell-shaped" curve that "fits" the data. This bell-shaped curve represents the *normal distribution curve* that you studied in Unit 19, *Working with Statistics.*

10

Mystery Data

These two graphs show the measurements of 24 individual members of some group of living things. The same data is represented as a bar graph and as a line plot. Can you come up with a theory about what this group might be?





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Stem and Leaf Plots

Stem-and-Leaf plots are a new way to quickly organize and display data. They are best used when there are more than 25 pieces of data. Statisticians use stem-and-leaf plots as a substitute for less informative histograms and bar graphs.

From stem-and-leaf plots it is easy to identify the largest and smallest values, outliers, cluster, gaps, the relative position of any important value, and the shape of the distribution.

In order to show you how to construct a stem-and-leaf plot, I will use a set of data that is a set of test scores from one of my classes this past semester.

TEST SCORES

100	98	100	88	64	86	70	100	82	100	74	100
84	86	84	72	92	82	82	67	77	84	59	67
54	96	83	71								

To construct and stem-and-leaf plot:

First, find the smallest value and the largest value.

The smallest value is 54 and the largest value is 100. Therefore we will chose our stems to be 5 through 10, the tens digits of the numbers.

Second, write these stems vertically with a line to their right.

```
 5 |
 6 |
 7 |
 8 |
 9 |
10 |
```

Third, separate each value into a stem and leaf and put the leaves on the plot to the right of the stem.

For example, the first value in the list is 100. Its stem is 10 and its leaf is 0. It is placed on the plot next to the 10 as shown. The second value is 98. Its stem is 9 and its leaf is 8. It is placed next to the 9. Continue until all data are placed on the plot.

```
5  |
6  |
7  |
8  |
9  | 8
10 | 0
```

```
5  | 9 4
6  | 4 7 7
7  | 0 4 2 7 1
8  | 8 6 2 4 6 4 2 2 4 3
9  | 8 2 6
10 | 0
```

Next, on a new plot arrange the leaves so they are ordered from smallest value to largest value. Place a key or explanation next to the graph.

```
5  | 4 9
6  | 4 7 7
7  | 0 1 2 4 7
8  | 2 2 2 3 4 4 4 6 6 8
9  | 2 6 8
10 | 0 0 0 0 0                6|7 means a score of 67.
```

If you turn the stem and leaf plot "on its side" you get a plot that resembles a bar graph or histogram. The stem and leaf plot is often better because it is easier to construct and all the original data values are displayed. You are now ready to ask yourself questions about the data. Are there clusters or gaps? How many had A's? B's? etc. Were there any unusual scores? Outliers?

On the next two pages you will find tables. The data in the tables are the ages of the best actors and actresses from 1928-1988. The age listed is their age when they received their Oscars. Construct a stem-and-leaf plot for the actresses and another for the actors. You can put them back to back as shown below.

```
Best actors    | 2    |    Best actresses
               | 3    |
               | 4    |
               | 5    |
               | etc. |
```

TABLE 1

Best Actresses, 1928–1988

Year	Actress	Movie	Age
1928	Janet Gaynor	*Seventh Heaven*	22
1929	Mary Pickford	*Coquette*	36
1930	Norma Shearer	*The Divorcee*	26
1931	Marie Dressler	*Min and Bill*	62
1932	Helen Hayes	*The Sin of Madelon Claudet*	32
1933	Katharine Hepburn	*Morning Glory*	26
1934	Claudette Colbert	*It Happened One Night*	29
1935	Bette Davis	*Dangerous*	27
1936	Luise Rainer	*The Great Ziegfield*	24
1937	Luise Rainer	*The Good Earth*	25
1938	Bette Davis	*Jezebel*	30
1939	Vivien Leigh	*Gone with the Wind*	26
1940	Ginger Rogers	*Kitty Foyle*	29
1941	Joan Fontaine	*Suspicion*	24
1942	Greer Garson	*Mrs. Minever*	34
1943	Jennifer Jones	*The Song of Bernadette*	24
1944	Ingrid Bergman	*Gaslight*	29
1945	Joan Crawford	*Mildred Pierce*	41
1946	Olivia de Havilland	*To Each His Own*	30
1947	Loretta Young	*The Farmer's Daughter*	34
1948	Jane Wyman	*Johnny Belinda*	34
1949	Olivia de Havilland	*The Heiress*	33
1950	Judy Holliday	*Born Yesterday*	28
1951	Vivien Leigh	*A Streetcar Named Desire*	38
1952	Shirley Booth	*Come Back, Little Sheba*	45
1953	Audrey Hepburn	*Roman Holiday*	24
1954	Grace Kelly	*The Country Girl*	26
1955	Anna Magnani	*The Rose Tattoo*	48
1956	Ingrid Bergman	*Anastasia*	41
1957	Joanne Woodward	*The Three Faces of Eve*	27
1958	Susan Hayward	*I Want to Live*	40
1959	Simone Signoret	*Room at the Top*	38
1960	Elizabeth Taylor	*Butterfield 8*	28
1961	Sophia Loren	*Two Women*	27
1962	Anne Bancroft	*The Miracle Worker*	31
1963	Patricia Neal	*Hud*	37
1964	Julie Andrews	*Mary Poppins*	30
1965	Julie Christie	*Darling*	24
1966	Elizabeth Taylor	*Who's Afraid of Virginia Woolf?*	34
1967	Katharine Hepburn	*Guess Who's Coming to Dinner*	60
1968	Katharine Hepburn	*The Lion in Winter*	61
1968	Barbra Streisand	*Funny Girl*	26
1969	Maggie Smith	*The Prime of Miss Jean Brodie*	35
1970	Glenda Jackson	*Women in Love*	34
1971	Jane Fonda	*Klute*	34
1972	Liza Minnelli	*Cabaret*	26
1973	Glenda Jackson	*A Touch of Class*	37
1974	Ellen Burstyn	*Alice Doesn't Live Here Anymore*	42
1975	Louise Fletcher	*One Flew over the Cuckoo's Nest*	41
1976	Faye Dunaway	*Network*	35
1977	Diane Keaton	*Annie Hall*	31
1978	Jane Fonda	*Coming Home*	41
1979	Sally Field	*Norma Rae*	33
1980	Sissy Spacek	*Coal Miner's Daughter*	30
1981	Katharine Hepburn	*On Golden Pond*	74
1982	Meryl Streep	*Sophie's Choice*	33
1983	Shirley MacLaine	*Terms of Endearment*	49
1984	Sally Field	*Places in the Heart*	38
1985	Geraldine Page	*Trip to Bountiful*	61
1986	Marlee Matlin	*Children of a Lesser God*	21
1987	Cher	*Moonstruck*	41
1988	Jodie Foster	*The Accused*	26

TABLE 2

Best Actors, 1928–1988

Year	Actor	Movie	Age
1928	Emil Jannings	*The Way of All Flesh*	44
1929	Warner Baxter	*In Old Arizona*	38
1930	George Arliss	*Disraeli*	46
1931	Lionel Barrymore	*A Free Soul*	53
1932	Fredric March	*Dr. Jekyll and Mr. Hyde*	35
1932	Wallace Berry	*The Champ*	47
1933	Charles Laughton	*The Private Life of Henry VIII*	34
1934	Clark Gable	*It Happened One Night*	33
1935	Victor McLaglen	*The Informer*	49
1936	Paul Muni	*The Story of Louis Pasteur*	41
1937	Spencer Tracy	*Captains Courageous*	37
1938	Spencer Tracy	*Boys' Town*	38
1939	Robert Donat	*Goodbye Mr. Chips*	34
1940	James Stewart	*The Philadelphia Story*	32
1941	Gary Cooper	*Sergeant York*	40
1942	James Cagney	*Yankee Doodle Dandy*	43
1943	Paul Lukas	*On the Rhine*	48
1944	Bing Crosby	*Going My Way*	43
1945	Ray Milland	*The Lost Weekend*	40
1946	Fredric March	*The Best Years of Our Lives*	49
1947	Ronald Colman	*A Double Life*	56
1948	Laurence Olivier	*Hamlet*	41
1949	Broderick Crawford	*All the King's Men*	38
1950	Jose Ferrer	*Cyrano de Bergerac*	38
1951	Humphrey Bogart	*The African Queen*	52
1952	Gary Cooper	*High Noon*	51
1953	William Holden	*Stalag 17*	35
1954	Marlon Brando	*On the Waterfront*	30
1955	Ernest Borgnine	*Marty*	38
1956	Yul Brynner	*The King and I*	41
1957	Alec Guinness	*The Bridge on the River Kwai*	43
1958	David Niven	*Separate Tables*	49
1959	Charlton Heston	*Ben Hur*	35
1960	Burt Lancaster	*Elmer Gantry*	47
1961	Maximilian Schell	*Judgment at Nuremburg*	31
1962	Gregory Peck	*To Kill a Mockingbird*	46
1963	Sidney Poitier	*Lilies of the Field*	39
1964	Rex Harrison	*My Fair Lady*	56
1965	Lee Marvin	*Cat Ballou*	41
1966	Paul Scofield	*A Man for All Seasons*	44
1967	Rod Steiger	*In the Heat of the Night*	42
1968	Cliff Robertson	*Charly*	43
1969	John Wayne	*True Grit*	62
1970	George C. Scott	*Patton*	43
1971	Gene Hackman	*The French Connection*	40
1972	Marlon Brando	*The Godfather*	48
1973	Jack Lemmon	*Save the Tiger*	48
1974	Art Carney	*Harry and Tonto*	56
1975	Jack Nicholson	*One Flew over the Cuckoo's Nest*	38
1976	Peter Finch	*Network*	60
1977	Richard Dreyfuss	*The Goodbye Girl*	32
1978	Jon Voight	*Coming Home*	40
1979	Dustin Hoffman	*Kramer vs. Kramer*	42
1980	Robert De Niro	*Raging Bull*	37
1981	Henry Fonda	*On Golden Pond*	76
1982	Ben Kingsley	*Gandhi*	39
1983	Robert Duvall	*Tender Mercies*	55
1984	F. Murray Abraham	*Amadeus*	45
1985	William Hurt	*Kiss of the Spider Woman*	35
1986	Paul Newman	*Color of Money*	61
1987	Michael Douglas	*Wall Street*	33
1988	Dustin Hoffman	*Rainman*	51

Complete the Back-to-Back Stem-and-Leaf Plot below and answer the questions before class tomorrow.

Problem Solving Applications:

BACK-TO-BACK STEM-AND-LEAF PLOTS

A **back-to-back stem-and-leaf plot** can be used to organize two sets of data so that they can be compared. The stems form the "backbone" of this kind of plot. This back-to-back stem-and-leaf plot shows age data for the first three U.S. presidents.

Age at Inauguration		Age at Death
	9	0
	8	3
	7	
1	6	7
7 7	5	
	4	

1. Copy and complete the back-to-back stem-and-leaf plot to include the data for all forty-one presidents.
2. How many presidents were inaugurated when they were in their fifties?
3. Who was the youngest president to be inaugurated? How old was he? Who was the oldest president to be inaugurated? How old was he?
4. Which president died the youngest? How old was he?
5. Describe any outliers, clusters, and gaps in the data.

AGES OF UNITED STATES [illegible] INAUGURATION [illegible] AT DEATH

Name	Term	Age at Inaug.	Age at Death
1. Washington	1789–1797	57	67
2. J. Adams	1797–1801	61	90
3. Jefferson	1801–1809	57	83
4. Madison	1809–1817	57	85
5. Monroe	1817–1825	58	73
6. J. Q. Adams	1825–1829	57	80
7. Jackson	1829–1837	61	78
8. Van Buren	1837–1841	54	79
9. W. H. Harrison	1841	68	68
10. Tyler	1841–1845	51	71
11. Polk	1845–1849	49	53
12. Taylor	1849–1850	64	65
13. Fillmore	1850–1853	50	74
14. Pierce	1853–1857	48	64
15. Buchanan	1857–1861	65	77
16. Lincoln	1861–1865	52	56
17. A. Johnson	1865–1869	56	66
18. Grant	1869–1877	46	63
19. Hayes	1877–1881	54	70
20. Garfield	1881	49	49
21. Arthur	1881–1885	50	56
22. Cleveland	1885–1889	47	71
23. B. Harrison	1889–1893	55	67
24. Cleveland	1893–1897	55	—
25. McKinley	1897–1901	54	58
26. T. Roosevelt	1901–1909	42	60
27. Taft	1909–1913	51	72
28. Wilson	1913–1921	56	67
29. Harding	1921–1923	55	57
30. Coolidge	1923–1929	51	60
31. Hoover	1929–1933	54	90
32. F. D. Roosevelt	1933–1945	51	63
33. Truman	1945–1953	60	88
34. Eisenhower	1953–1961	62	78
35. Kennedy	1961–1963	43	46
36. L. B. Johnson	1963–1969	55	64
37. Nixon	1969–1974	56	—
38. Ford	1974–1977	61	—
39. Carter	1977–1981	52	—
40. Reagan	1981–1989	69	—
41. Bush	1989–	64	—

CHECK UNDERSTANDING

Why are there dashes in the Age-at-Death column for the last five presidents?

Why is there a dash in the Age-at-Death column for the twenty-fourth president, Cleveland?

6. Research two sets of data that can be compared. You might use, for example, the numbers of games won by the teams in two leagues or the amounts of fat and cholesterol found in various foods. Organize the data into a back-to-back stem-and-leaf plot.
7. Exchange the plot you made for Exercise 6 for a classmate's plot. Write a description of the data in your classmate's plot.

BEST COPY AVAILABLE

DATA DISTRIBUTION

On our road to *quality assurance* (QA) and *process control* (PC), we have seen that items of information—**data**—play an important role. Data is collected by a variety of methods, including surveys (or polls), experiments (or observations), and direct measurements. After the data is collected, it is organized. Usually, data is displayed in charts and graphs to make it easier to understand and describe. In this section we will try to do exactly that—understand and describe data.

In Unit 19, *Working with Statistics*, you learned that there are two basic ways to look at data. One is to see what happens to the majority of the data—described by *measures of central tendency*. The other is to look at how the data is *spread out* or distributed—known as *measures of dispersion*. **Central tendency and dispersion** represent important characteristics we use to describe a collection of data.

Measures of central tendency

Example 7:
Revisiting measures of central tendency

The measures of *central tendency* of a distribution are the numerical values that describe the central position of the data. The three measures of central tendency are the *arithmetic mean*, the *median*, and the *mode*.

Let's do a quick review of these *measures of central tendency* by considering the salaries of 11 employees in a small company, the Dracut Electronics Company.

Salary Data for Dracut Electronics Company

Employee #	Salary	Employee #	Salary
1	$18,000	6	$28,000
2	$20,000	7	$30,000
3	$22,000	8	$34,000
4	$24,000	9	$40,000
5	$24,000	10	$45,000
		11	$60,000

Arithmetic mean

The *arithmetic mean* ($\bar{x}$) is probably the most common measure of central tendency. To calculate the mean, simply add all the data values and divide by the number of data values:

$$\text{Arithmetic mean } (\bar{x}) = \frac{\text{Sum of all salaries}}{\text{\# of employees}} = \frac{\$345{,}000}{11} = \$31{,}364$$

Although the arithmetic mean of $31,364 gives us *some idea* of the average salary earned at Dracut Electronics, it does not—*by itself*—give us "complete information." For example, 7 employees actually earn less than the "average" while only 4 employees earn more. Clearly, the higher salary figures ($40,000; $45,000; $60,000) *skew the data* by "loading" it at the higher values.

Median

The *median (Md)* helps us locate the "center" of all the data. The median divides the set of *ordered* data values, so that an equal number of values fall above and below the "middle" data value.

For the eleven employees at Dracut Electronics, Employee #6 locates the middle of the distribution (5 employees above, 5 employees below). The sixth ordered salary is $28,000, so the median is $28,000. Notice that the median is $3,364 less than the arithmetic mean ($31,364). That is a "signal" that there may be some skewness to the data distribution. In our case, it means there may be some "loading" of salaries at the top.

For an odd number of data items (in our case, salaries) the middle item is always easy to identify. For the sorted salaries of 11 employees—as we've just seen—Employee #6 divides the distribution into two parts, and so is the median value. But what if Dracut Electronics had 12 employees? In that case, there would be no single salary at the "center." In fact there would be two, the 6th salary and the 7th salary. Below these two there would be 5 and above these two there would be 5. In such *even-numbered* distributions, the median is simply the *arithmetic mean* of the two middle items. For the case of 12 Dracut Electronics Company employees, then, the median would be the average or mean of the salaries for Employee #6 and Employee #7.

Mode

The *mode (Mo)* of a set of ordered data is that value which occurs most often—that is, with the highest frequency. For Dracut Electronics, the mode is $24,000 since it occurs twice. All other salaries occur only once. Note that it is possible for a set of data to have more than one mode, or even *no* mode. If Employee #5 received a raise to $26,000, the salary data would have no mode. Or if Employee #1 received a raise to $20,000, the data would have two modes—one at $20,000 and one at $24,000. This distribution might then be called *bimodal.*

Study Activity: Determine the arithmetic mean ($\bar{x}$), the median (*Md*) and mode (*Mo*) for the following set of test scores— earned by Danny L. in *Applied Mathematics.*

Date	Score	Date	Score
Sep 12	73	Oct 17	50
Sep 19	82	Oct 24	73
Sep 26	60	Oct 31	75
Oct 3	82	Nov 7	82
Oct 10	78	Nov 14	85

When the median, mode, and mean of a distribution of data are all equal, we have a very special case. We say that the data has a **normal distribution**—a perfect bell-shaped curve. For the Dracut Electronics Company employees, the *median* salary ($28,000) and the *mode* ($24,000) are both smaller than the arithmetic *mean* ($31,364). If the mode and median are lower in value than the mean, the distribution curve is not bell-shaped; it is *skewed to the right.* If the mode and median are higher in value than the mean, the distribution curve is *skewed to the left.* The three distributions of data values shown in Figure 32-17 demonstrate the three cases discussed above.

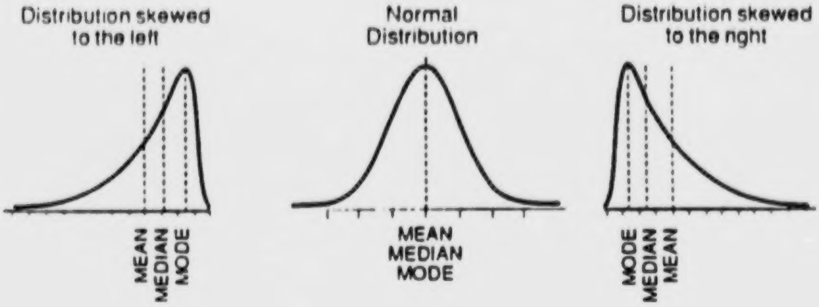
Distribution skewed to the left
MEAN
MEDIAN
MODE
Normal Distribution
MEAN
MEDIAN
MODE
Distribution skewed to the right
MODE
MEDIAN
MEAN

Figure 32-17

Measures of central tendency for three different distributions

MEASURES OF CENTRAL TENDENCY

Often when you have numerical data, you may want to know what the typical value is, what number occurs most often, where the numbers tend to clump together, or what the middle number might be. All of these ideas are ways to talk about the central tendency of the data. Measure of central tendency use just one number to represent all the numbers in the data.

MODE: the number that occurs most frequently in a set of numbers. Note: a set of numbers may have no mode, one mode, or more than one mode.

MEDIAN: the middle point. The median is a point that divides the data so that exactly half the data are above the point and half are below the point. To find the median, arrange the data from the lowest to the highest. Then by count to the middle number. If there are two middle numbers, add them and divide by 2.

MEAN: average. Add up all the data and divide by how many there are. It is usually represent by an x with a bar over it: $\overline{x}$

QUICK CHECK:

Find the mode, median, and mean of the data below.

18 35 78 42 28 75 55 46 35 24

We will now collect some of our own data for the class and find the mean, median, and mode. Turn to the next page and read the directions for the tiddly-wink snap and the fifty-meter backwards run. **WAIT FOR FURTHER INSTRUCTIONS!**

Classroom Pentathalon

This activity consists of five events for you to perform. The best performance in each event will be scored 100 points. The remaining performances are scored asa percent of the best performances.

The five events of this pentathalon are:

1. Cotton ball throw
   Throw a ball of cotton as far as you can. Measure the distance from the starting line to the point where the cotton ball first touches the floor.

   Stand with your toes on but not over the starting line. Throw the cotton ball. Spotters will decide where it first touches the floor, and that distance will be measured to the nearest centimeter.

2. Paper toss score
   From a distance of 4 meters record how many wads of paper you can throw, one at a time, into a wastebasket in 30 seconds.

3. Tiddley-wink snap
   Snap a tiddley-wink as far as possible. Measure the distance from the starting line to the point where the tiddley-wink first touches the floor.

   Spotters will determine where the tiddley-wink first touches the floor and will measure from the starting line.

4. Fifty-meter backwards run
   Timers will time your backwards "run" to the nearest tenth of a second using a stop watch.

5. Rubber band snap
   Snap a rubber band as far as you can. Measure the distance from the starting line to the point where the rubber band first touches the floor.

   All competitors will use the same type and size of rubber band as provided by Miss Howell. Spotters will determine where the rubber band first touches the floor, and the distance will be measured to the nearest centimeter.

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Name ______________________________

Period No. _________

Personal Record of Classroom Pentathalon
Final Summary

EVENT: Cotton Ball Throw

My Best distance ________________ Best Distance ______________

My score ____________________

EVENT: Paper Toss

My Count _________________ Best Count ___________________

My score ____________________

EVENT: Tiddley-Wink Snap

My Best distance _______________ Best distance _______________

My score ____________________

EVENT: Fifty meter Backwards Run

My time ____________________ Best time ________________________

My score ____________________

EVENT: Rubber Band Snap

My Best distance ______________ Best distance ________________

My score ____________________

MY PENTATHALON SCORE: ______________________________________
(Sum of scores from all five events)

22

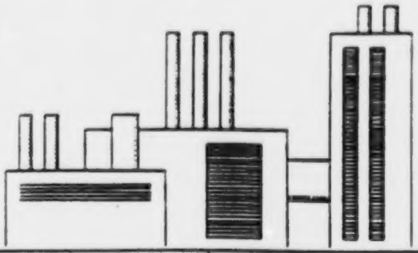
WHAT DO YOU THINK ?

Melcher Manufacturing Company boasts that they pay an average salary of $10,000 to their employees.

Is the company telling the truth?

1) To help you decide, use the salary schedule to find
   mean salary: ________
   median salary: ________
   mode salary: ________

2) Which do you think is a more representative number for these salaries, the mean, median or mode? ______________



TYPE OF JOB	NUMBER EMPLOYED	SALARY
PRESIDENT	1	$133,000
VICE-PRESIDENT	2	$ 70,000
PLANT MANAGER	3	$ 25,000
FOREMAN	12	$ 8,000
SKILLED OPERATOR	21	$ 6,000
UNSKILLED OPERATOR	36	$ 5,000

Sometimes it is more helpful to know the median; sometimes the mean; other times the mode.

1) If you wanted to find the total amount spent on junk food for a week by your class, would you want to know the mean, median or mode amount spent by the class?

2) If you wanted to know if you read more or less books per month than most people in the class, would you want to know the mean, median or mode?

3) The Big Wheel roller skating rink is ordering new skates. Which would be more useful to know, the mode, mean or median skate size?

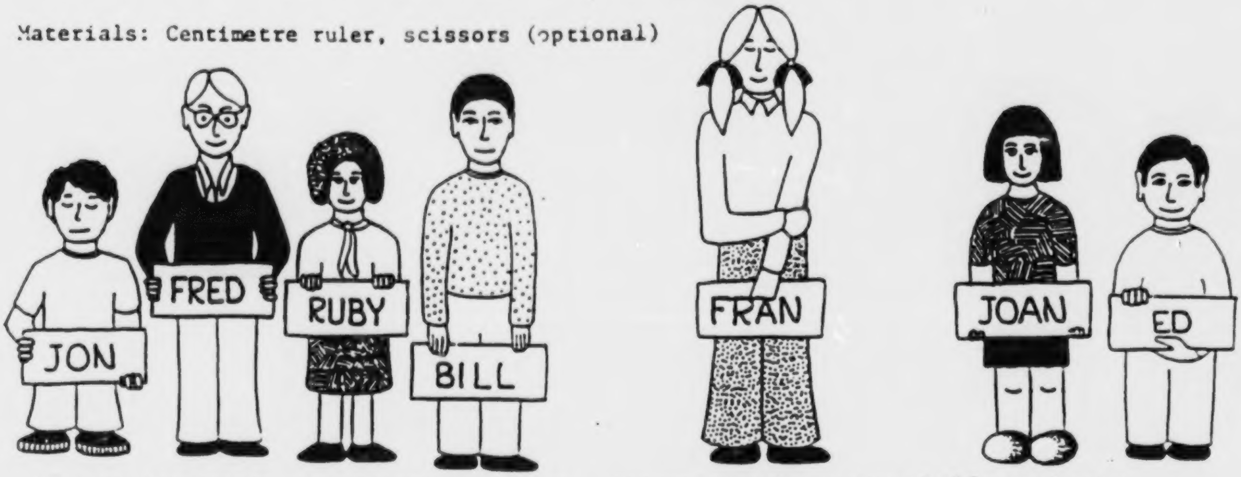
4) The members of the Four Star riding club sold candy bars to finance a trip. The sales are shown in the table. Which best represents the number of bars sold by each member: the mode, mean or median?

NUMBER OF BARS SOLD	NUMBER OF MEMBERS
5	1
15	8
20	5
30	4
40	2
200	1

5) You want to know which country has a large portion of people with low incomes. Which is most helpful to know for each country: the mean, mode or median income?

THE STUDENT IN THE MIDDLE

Materials: Centimetre ruler, scissors (optional)



1) Find the height of each student above. Measure to the nearest half centimetre.

Jon ________ Ruby ________ Fran ________ Ed ________

Fred ________ Bill ________ Joan ________

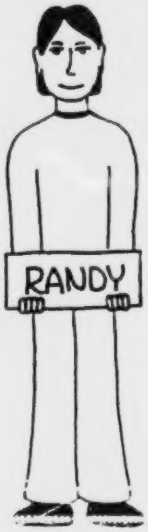
2) Arrange the heights in order from smallest to largest. ___,___,___,___,___,___,___,

3) Circle the middle height in #2.

WHEN NUMBERS ARE ARRANGED IN ORDER THE MIDDLE NUMBER IS THE MEDIAN.

4) Which student has the median height? ________

5) Randy wants to join the group. Find Randy's height. ________



6) What is the median height of the group now? ______

SINCE THERE IS AN EVEN NUMBER OF HEIGHTS THE MEDIAN IS HALF WAY BETWEEN THE MIDDLE TWO HEIGHTS.

7) Does any student have this median height? ______

8) Wilbur walks over to the group. He is 6 cm tall. Draw Wilbur next to Joan. Find the median height of the group. (Include Randy.) ___________

9) Does any student have the median height? ______

10) Cindy joins the group. She is 7 cm tall. Draw Cindy next to Bill. Find the median height of the group. ________

11) Does any student have the median height? ________

Measures of dispersion

Example 8:
Revisiting measures of dispersion

Let's now review two important *measures of dispersion*—**range** and **standard deviation**. You learned about these in Chapter 19, *Working with Statistics.* Whereas *measures of central tendency* help us understand how data clumps around the middle of the distribution, *measures of dispersion* help us understand how the data is spread out.

Let's examine the following data from a company that manufactures pencils. We want to determine both the range and standard deviation for the production of pencils in a one-hour run.

Data on lengths of pencils

Length of pencil (cm)	Frequency (# of pencils)
18.5	20
18.6	50
18.7	110
18.8	200
18.9	315
19.0	360
19.1	315
19.2	200
19.3	110
19.4	50
19.5	20

The histogram in Figure 32-18 shows the frequency data from above.

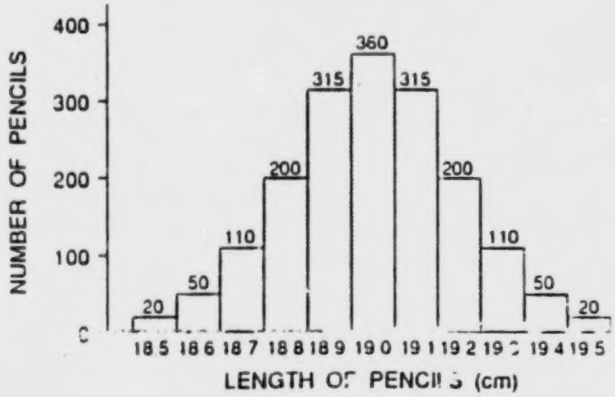


Figure 32-18
Histogram of pencil lengths

If we examine the table of data and the histogram we find the following:

- The *total* number of pencils measured is 1750.
- The *range* of lengths for this production varies from a low of 18.5 cm to a high of 19.5 cm. The range is defined as the highest value (X_H) minus the lowest value (X_L), or

  $$R = X_H - X_L$$

  We see that the range for pencil lengths is 19.5 cm – 18.5 cm, or $R = 1.0$ cm.
- The histogram is *perfectly symmetrical,* so that the *mean, median,* and *mode* all have the same value, i.e., 19.0 cm.

Suppose that on a different day, a run of pencil lengths yields the histogram of *number of pencils* versus *length* shown in Figure 32-19. Note the difference in the number of pencils that are measured to have lengths of 18.5 cm, 18.6 cm, and so on, as compared to the measurements given in Figure 32-18.

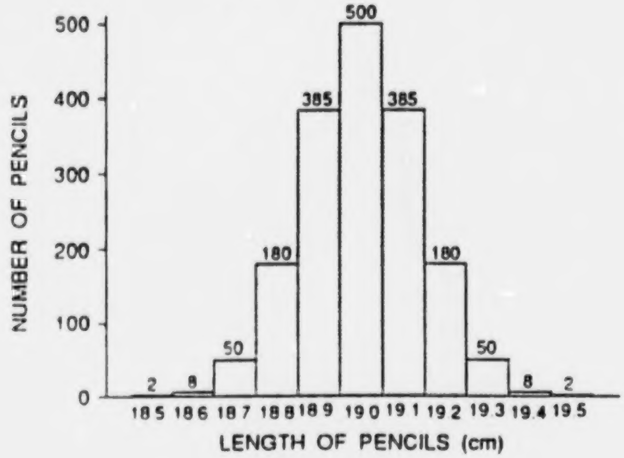


Figure 32-19
Histogram for production of pencils—different run

Looking at this graph, we see that:

- The *total* number of pencils measured is 1750 (same as before).
- The *range* is from 18.5 cm to 19.5 cm, or 1 cm (same as before).
- The histogram is also *symmetrical*—showing the mean, median, and mode at 19.0 cm (same as before).
- The *frequency distribution* is *different.*

Even though many characteristics of the histograms for Figures 32-18 and 32-19 are identical, the *frequency distributions* are very *different*. The difference is due to the fact that the number of pencils in each cell has changed. But note carefully, neither the *range* nor the *measures of central tendency* for the two distributions "signals" a difference. These characteristics are the same for both distributions. So, we need to employ another *measure of dispersion*. We need a measure that will give us some information about how individual values vary in relation to the central tendency. As you know, **standard deviation** is that characteristic.

Let's use the formula to calculate the standard deviation of the pencil data of Figure 32-18. Study the calculations in the table here. The formula for σ needs the mean. With the data in frequency form, you multiply the frequency f by each *x-value* to find the value of Σx. Then you use the formula for the mean:

Table 2. Finding $\bar{x}$ and σ from frequency data

x	f	$x \cdot f$	dev^2	$dev^2 \cdot f$
18.5	20	370.0	0.25	5.00
18.6	50	930.0	0.16	8.00
18.7	110	2057.0	0.09	9.90
18.8	200	3760.0	0.04	8.00
18.9	315	5953.0	0.01	3.15
19.0	360	6840.0	0.00	0.00
19.1	315	6016.0	0.01	3.15
19.2	200	3840.0	0.04	8.00
19.3	110	2123.0	0.09	9.90
19.4	50	970.0	0.16	8.00
19.5	20	390.0	0.25	5.00
Sum:	1750	33250.0		68.10
Avg:		19.00		

$$\bar{x} = \frac{\Sigma x}{N} = \frac{33{,}250}{1750} = 19.00$$

Next find the squared deviations from the mean, $(x - \bar{x})^2$, for each x-value. Then find the total squared deviations by multiplying the frequency f by each squared deviation, as $(x - \bar{x})^2 \cdot f$ or $(dev)^2 \cdot f$. Finally, use the formula to find the standard deviation.

$$\sigma = \sqrt{\frac{\Sigma(x - \bar{x})^2 \cdot f}{N}} = \sqrt{\frac{68.10}{1750}} = 0.20 \text{ (rounded)}$$

Study Activity: Use the table above as a pattern to compute the standard deviation of the frequency data in Figure 32-19. Compare the result with the standard deviation from the data of Figure 32-18.

MEASURES OF VARIABILITY

A central tendency does not tell the whole story about a situation. It is also useful to look at how the numbers vary, or change.

RANGE: the difference between the highest and lowest values.

$$R = X_h - X_L$$

STANDARD DEVIATION: measures the scatter or spread of the data.

To find standard deviation we will use a formula:

$$\sigma = \sqrt{\frac{\sum (x-\bar{x})^2}{n}}$$

a. Add all the numbers together and find the mean x.
b. Calculate the value of $(x - \bar{x})$ for each number x in the set.
c. Calculate the value of $(x - \bar{x})^2$ for each number.
d. Find the value of $\sum(x - \bar{x})^2$ by adding all the values of $(x - \bar{x})^2$.
e. Divide the value you just found by N (number of data values).
f. Take the square root of the value in step e to get the standard deviation

Let's do a short example of 10 data values

	x	$x - \bar{x}$	$(x - \bar{x})^2$
	25		
	20		
	12		
	34		
	54		
	30		
	35		
	32		
	20		
	10		
Totals			

Standard deviation =

USING A CALCULATOR TO FIND MEAN AND STANDARD DEVIATION

Let's use the same set of data and find the mean and standard deviation by calculator.

To put your calculator in the statistics mode press **3rd [STAT 1]**

Enter the data:

25 $\Sigma+$
20 $\Sigma+$
12 $\Sigma+$
34 $\Sigma+$
54 $\Sigma+$
30 $\Sigma+$
35 $\Sigma+$
32 $\Sigma+$
20 $\Sigma+$
10 $\Sigma+$

If you make a mistake as you enter the data, type in the data again and press **2nd** $\Sigma-$. Then enter the data correctly and press $\Sigma+$

To find the mean press **2nd $\bar{x}$**

To find the standard deviation press **2nd σxn**

You can also find the sum of the data values by pressing **2nd x**

2nd n will tell you how many data values you have entered.

To get out of the statistics mode turn off your calculator.

Do the following exercise on your calculator.

The table below lists temperatures that you obtained in a refrigerated dairy case during a six-day period, twice each day.

DAY	TEMPERATURE, (F°)	
1	38	39
2	38	40
3	40	39
4	40	38
5	38	39
6	38	40

a. What is the range of the temperatures?

b. What is the mean temperature?

c. What is the median temperature? (be sure to put data in order first!)

d. What is the mode of the temperature data?

e. What is the standard deviation of the temperature?

f. If dairy products should stay between 38F and 40F, does this data suggest that these will exist 95% of the time? (Assume a normal distribution. Take 2 times the standard deviation and add it to the mean. Take 2 times the standard deviation and subtract it from the mean. Does all (or most) of the data fall between these two values?)

Let's do the reaction time activity on the following pages.

PRACTICING THE SKILLS

Laboratory Activities

Use the mathematics skills you have learned to complete one or all of the following activities:

Activity 1: Comparing reaction times

Equipment

Meterstick
Calculator (with "statistics" keys)
Drawing kit (Accu-Line™)

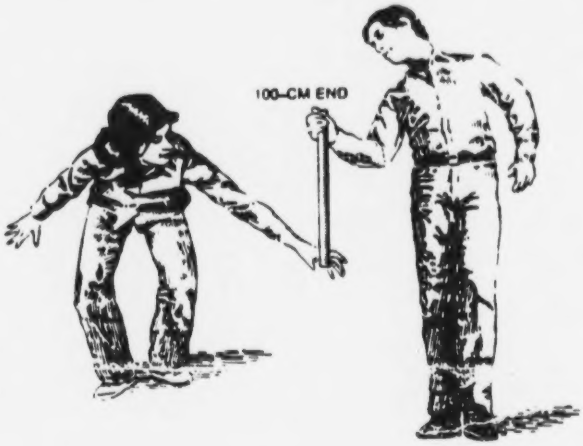
Statement of Problem

A *reaction time* is a measure of how long it takes you to do something (*such as step on the brakes*) after you receive a certain signal (*such as see a child start across the street in front of you*). Reaction times vary from one person to the next. Reaction times, from one measurement to the next, also vary for the same person.

In this laboratory you will measure reaction times for a "specific event." Then, based on the data for your group and your class, you will calculate measures of *central tendency* and *variability*.

Procedure

a. The reaction time to be measured in this laboratory is how long it takes you to stop a stick that starts falling between your thumb and forefinger. Look at the drawing shown below. One member of the group should hold the meterstick at the 100-cm end. Another member of the group—whose reaction time is being measured—



should place a hand at the bottom of the stick as shown in the drawing, with thumb and forefinger each *two-centimeters* to the side of the 0-cm mark. When the person holding the top drops the stick, the other person, looking only at the bottom of the stick, catches the stick as quickly as possible by pressing thumb and forefinger together.

b. The length of meterstick from the 0-cm end to the "catch" position is proportional to the elapsed time from moment of "drop" to moment of "catch." Thus, you can use this length as a "measure" of the reaction time. For each "drop" read the **millimeter mark that is just visible above the thumb.** Use this reading as an indication of the reaction time. You can see that a lower reading, 75 mm for example, represents a faster reaction time than a higher reading, 92 mm for example.

c. Have each member of the group catch three "drops." Record the meterstick readings on a sheet of data paper.

d. When all groups have completed their measurements of reaction times, write the meterstick readings for the entire class on the chalkboard. These readings become the *data set* for the class.

Calculations

a. Determine the **mode** and **median** of reaction times for the *entire class*.

b. Use a calculator with "statistics" keys and calculate the **mean** and **standard deviation** of reaction times for the *entire class*.

c. Repeat the calculations in (a) and (b) for your own **group** data.

d. How do the mean and standard deviation for your group compare with those for the class?

e. Does your own reaction time fall within ± one standard deviation of the class mean? Of the group mean?

f. Divide the reaction times for the class data into 5 or 6 convenient intervals (for example, 50-59 mm, 60-69 mm, 70-79 mm and so on) and use your drawing kit (Accu-Line™) to make a **histogram** of the "reaction times" for the entire class. Does the data shown in the histogram "fit" a normal curve?

Challenge When an object falls freely from rest, the distance (S) it falls in a time (t) is given by the formula:

$$S = \frac{1}{2} g t^2$$

You can use this formula to convert the *meterstick reading* you obtained to an *actual reaction time*. First solve the formula $S = {}^1/_2\, gt^2$ for t (that is, rearrange the formula to isolate t) and then substitute in the following values:

- For S, substitute the value of the meterstick reading, in units of **centimeters.** (If your thumb and forefinger are opposite the 0-cm mark at the start of the drop, the meterstick reading is equal to the distance the stick dropped.)
- For g, substitute the value 980 cm/sec^2.
- Solve the rearranged equation for the time t. The value for t will be in seconds and will equal your reaction time.

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ANALYSIS OF DATA

In earlier sections we discussed what we meant by a *process* and distinguished it from its outcome, the *product*.

Every process involves a variety of factors. These are:

- People employed
- Methods utilized
- Machines used
- Materials used
- Measurements taken

These factors contribute to the behavior of the process. They inevitably affect the product itself. When a process is "*in control,*" it produces products over time that may vary, but always *consistently* within an expected range. The term *consistently* means that we can predict the future behavior of the process, and thus its outcome, with a certain degree of confidence. An *inconsistent* output implies that some change in process has taken place. This change usually can be traced to the:

- Operator of the equipment
- Methods of operation
- Machine itself
- Raw materials used
- Measurement devices

The above causes are referred to as *assignable* or *nonrandom* causes.

However, as we know, every process has some *variation* in it. When the variation is small and its cause remains undetectable, we call it *random* or *natural variation*. Generally, by trying to correct natural variation in the process, we only make things worse.

If *assignable* causes cannot be found for products with variation beyond acceptable limits, the process itself must be improved, perhaps automated. If we *eliminate* causes of *nonrandom variation*, only natural variation will be left—and the process will be "*in control.*"

Thus an "*in control*" process simply implies that we have been able to bring all assignable causes of variation, as named above, within acceptable limits. In the next section we will discuss what those limits are.

Working with distribution curves

One of the most important things we can do with data collected from a process is to examine the distribution of the data values. You've seen how skewed distributions look, and the effect they can have on the measures of central tendency and dispersion. But quite often the distribution of data is not skewed. A histogram of the data will be symmetrical and the shape of the distribution will resemble a bell-shaped curve. In that case, the measures of central tendency (the mean, median, and mode) and the measures of dispersion (the range and standard deviation) take on special significance.

The **normal curve** (ideal case) is a *symmetrical, bell-shaped curve* with the *mean*, *median*, and *mode* having the same value. Figure 32-20 shows an "ideal" normal distribution curve.

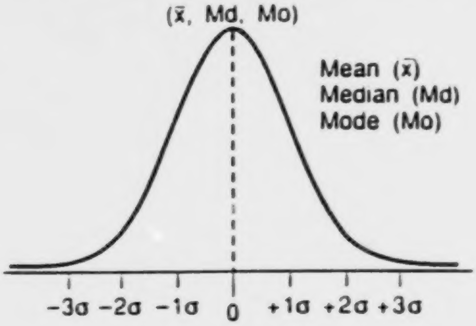


Figure 32-20
"Ideal" normal distribution curve

You've seen distributions formed by histograms. Suppose a histogram of your data values forms a bell-shaped curve like that in Figure 32-20. If so, you could say that your data has a **normal distribution**.

Look at the two points where the normal curve in Figure 32-20 seems to almost touch the horizontal axis. Let's consider those points to be the "ends" of the normal curve. Now, if you divide the overall width of the curve into six equal sections, each section will be one standard deviation (σ) wide. The curve is 3 σ wide on the left, and 3 σ wide on the right, or a total width of 6 σ. (See the horizontal axis labels in Figure 32-20).

If we know the value of the standard deviation, mathematics tells us that approximately 68% of the data values will be contained within plus and minus one standard deviation from the center. See Figure 32-21.

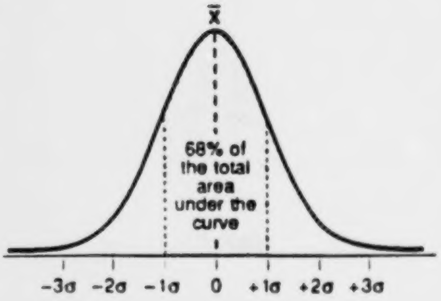


Figure 32-21
Area under a normal distribution curve between $+1\sigma$ and -1σ

If we extend the region to plus and minus two standard deviations, we find that approximately 95% of all data values will be located between these two points. See Figure 32-22.

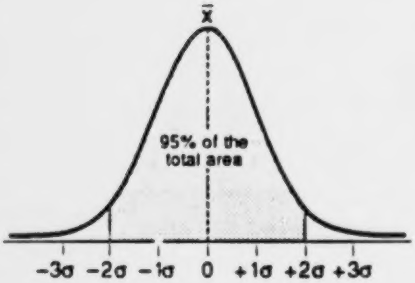


Figure 32-22
Area under a normal distribution curve between $+2\sigma$ and -2σ

Finally, 99.7% of all data values—almost all—will be contained within plus and minus three standard deviations of the center, as shown in Figure 32-23.

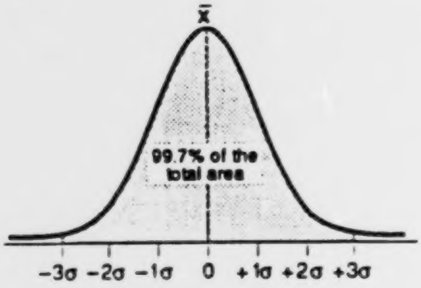
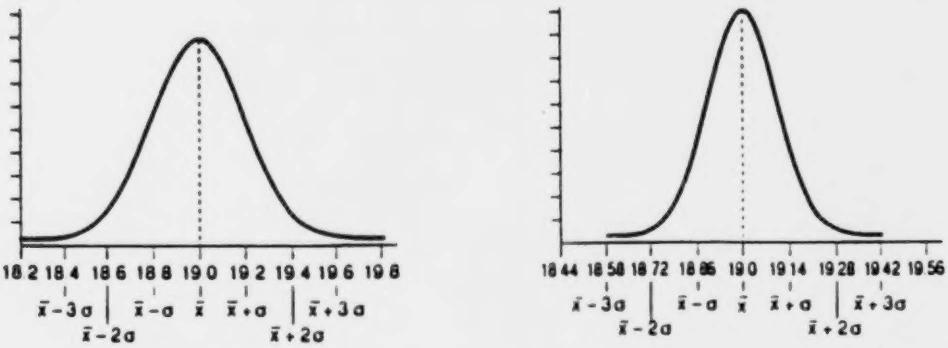


Figure 32-23
Area under a normal distribution curve between $+3\sigma$ and -3σ

So the *standard deviation* is a number that tells us about the *spread of data* for a given process. Let's return to the pencil-length data as shown in Figure 32-24 below and compare their standard deviations.



a. A process with $\bar{x}$ = 19.00 cm, and σ = 0.20 cm

b. A process with $\bar{x}$ = 19.00 cm, and σ = 0.14 cm

Figure 32-24

Two different processes having the same $\bar{x}$ but different σ

Both processes have normal, bell-shaped curves, with the *same* center or mean. Yet the standard deviation is 0.20 cm for one and 0.14 cm for the other. So we see that the *greater the standard deviation*, the *greater the spread*. Also note that almost all of the data values (99.7%) are contained between $\bar{x} - 3\sigma$ and $\bar{x} + 3\sigma$.

PRACTICING THE SKILLS

Laboratory Activities

Use the mathematics skills you learned to complete one or all of the following activities.

Activity 1: Pouring water into unmarked cups

Equipment

Disposable drinking cups, 3-oz capacity, nine
Graduated cylinder, 500-ml capacity
Beaker, 1000 ml
Absorbent paper towels
Waterproof tray, e.g., cookie sheet (optional)
Drawing kit (Accu-Line™)
Calculator

Statement of Problem

In the workplace, workers must maintain a certain *standard* without making an actual measurement. Workers make a "visual estimate" and produce the desired result to the best of their ability. Workers therefore seek a method to attain the desired results with the least amount of variation.

In this activity you will *simulate* such a task. The "standard" will call for you to fill each of nine unmarked cups with exactly 50 ml of water. You will attempt the nine fillings under different conditions and examine the accuracy and variation of the process.

Procedure

a. Fill the graduated cylinder with precisely 50 ml of water. Pour this water into one of the drinking cups. Let everyone in your lab group study the level of water in the cup for a few seconds and make a "mental note" of the water level. Then empty the water from the cup. Do ***not*** mark the nine cups in any way.

b. Fill the 1000-ml beaker about ⅔ full with water.

c. Arrange the nine drinking cups on a waterproof tray or paper towels to minimize the effects of spills. For the first arrangement, place the cups in three rows of three each a 3 × 3 arrangement, as shown in Figure 1.

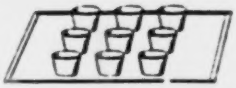


Figure 1
Arranging cups

d. Using the 1000-ml beaker, try to pour exactly 50 ml of water into each cup on the tray. As you pour:

- Try to remember what the *50-ml standard fill* looks like.

- Leave the cups on the tray as you pour—do not pick them up.
- Make only *one* attempt at each cup. Do not return to add water to—or remove water from—a cup.
- Don't take an unusually long time to fill each cup. Remember, "time is money" in the workplace.
- If you empty the 1000-ml beaker, refill and continue.

e. Measure the amount of water you poured into each cup by emptying its contents into the graduated cylinder. Make a Data Table using your Accu-Line™ drawing kit. Record the amount to the nearest milliliter in your Data Table with tic marks, as shown in the example. (You can save the water for reuse by returning it to the 1000-ml beaker.)

f. Restore the arrangement of empty cups and repeat Steps **d** and **e** with other members of your group. Tabulate all the data for all members of the group on the Data Table. (There is no need to identify the data from each separate member.)

g. Now change the arrangement of cups on the tray. Make one long row of nine cups. If there is not enough room on your tray for one row, use two rows. See Figure 2. Repeat Steps **d**, **e**, and **f**. Record your results in the Data Table for the "1 × 9" arrangement.

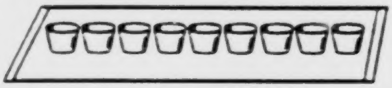


Figure 2
Arranging cups in one row

h. Finally, repeat Steps **d**, **e**, and **f**—filling a *single cup* at a time. A fellow student will place one cup at a time on the tray for you to fill. After you have filled the cup, your helper should remove it and place another empty one on the tray. Repeat this for all nine cups. Record your results in the Data Table for the "single" arrangement.

NOTE: After several fillings, paper cups may become soggy and lose their rigidity. You may need to replace used cups with fresh ones.

Data Table

Amount poured (ml)	Example tic marks	Arrangements		
		3 × 3	1 × 9	Single cups
40				
41				
42				
43				
44				
45	|			
46	|			
47	||			
48	|			
49	𝍸			
50	𝍸 |			
51	𝍸 𝍸 ||			
52	|||			
53	|			
54				
55	|			
56	|			
57	|			
58	|			
59				
60				

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i. Use paper towels to clean up any spills. Your teacher will tell you whether or not to discard the used cups.

Calculations

a. Use the techniques given in the text to compute the mean $\bar{x}$ and standard deviation σ for the frequency distribution of *each arrangement*. (Refer to the discussion of Figures 32-18 and 32-19 to help you calculate σ from a frequency distribution.)

b. For each arrangement, compute the process capability, 6σ. Which of the arrangements yields the *best* process capability? the *worst*?

c. Suppose the specification and tolerance for this process were given as 50 ml ± 10 ml. Compute the *Capability Index* for each of the arrangements.

Student Challenge

What type of data did you collect in this activity, *attribute data* or *measurement data*? Defend your answer.

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SUMMARY

Many people use numerical facts to help them make decisions. A collection of facts (or data) is more helpful if the data are arranged and organized to make it easier to see what is happening.

Statistics give you many ways to organize data into information that you can use to make decisions. One way to organize data is to find one number that represents all the numbers. This representative number tells the central tendency of the data. The mode, median, and mean of the data can all be used to report central tendency. You can choose which one to use depending on the data, and on what you want to know.

The mode works best when you want to find the most characteristic value in the group -- which one occurs the most. The median works best when you want to find the middle value in the group -- which one divides the data in half. The mean works best when you want to find a value that gives a numeric average of the data.

To find the mean of a set of values, add the individual values and divide by the number of values. A mean reflects a typical number in the data when there are no extremely high or low values.

To find the median of a set of values, arrange the values in order of size and find the middle point that divides the values into two equal parts. If the middle point is between two values, use the midpoint between them. The median reflects a typical number for data that have some extreme values.

To find the mode of a set of values, choose the value that occurs most frequently. A set of data may have no mode, one mode, or more than one mode. The mode reflects a typical value for data that have most of the numbers grouped around values fairly close to each other.

In addition to the central tendency, the variability of the data also gives you information. The range of the data is one measure of variability.

Many set of facts, when you make a graph (histogram or stem-and-leaf) fall into a "bell-shaped" pattern called a normal curve. If the data fit a normal curve, then you can calculate another measure of the variability of the data called the standard deviation. For any data that fit a normal curve, 68% of the data fall within one standard deviation from the mean, or center value. And 95% of the data fall within two standard deviations from the mean.

Statistics help you support your opinions and decisions with facts. They help you draw general conclusions about a total group of numbers by looking at part of the numbers in the group.

APPLIED MATH

WEEK TWO

RIGHT TRIANGLES

Introduction

If you stand on a downtown street corner and look around, you can see triangles everywhere. Triangles are used to brace corners, add strength to buildings, and support signs. They are used in building homes, offices, dam, and towers -- and they are used also in navigation to help airplanes and ships find their exact position.

People have known for a long time that triangles are important and useful. Long before people learned how to print books or use motors, and before they knew about germs or circulation of blood in the human body, they knew about the mathematics of triangles. The Greeks, more than 2000 years ago, worked out most of the geometry and mathematics still used today with triangles.

Understanding Right Triangles

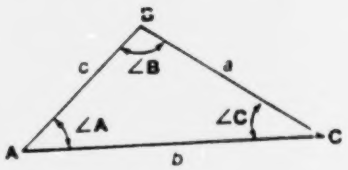
Recall what you already know about triangles in general.

1. All triangles have three sides and three angles. The three sides lie in the same plane.
2. The sum of the measures of the three angles of any triangle is 180.
3. The perimeter of a triangle is equal to the sum of the lengths of the three sides.
4. The area of a triangle is equal to the product of one-half the base times the height.
5. All right triangles have one right angle, measuring 90. The sides that form the right angle are perpendicular to each other.

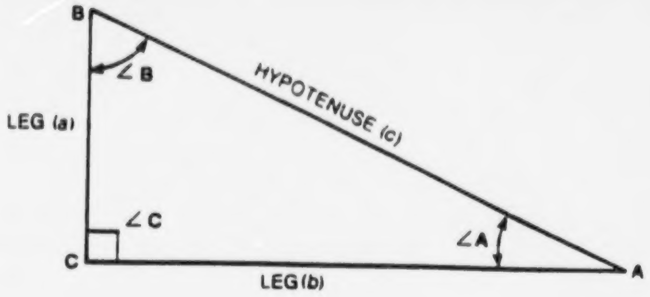
Labeling triangles

Recall how to label triangles.

1. The three vertices of the triangle are often labeled with capital letters such as A, B, and C.
2. The triangle is referred to as ABC.
3. The sides opposite the angles are often labeled with lower case letters such as a, b, and c. Note that a = length of BC, b = length of AC, and c = length of AB.
4. The three angles of the triangle are often labeled with the appropriate vertex letter, using the symbol "<" for angle, as <A, <B, and <C.



Right triangl~~es are~~ labeled the same way.



The following facts about right triangles are important for you to know.

Each right triangle has one right angle (90°), usually labeled <C.
The side opposite the right angle (always the longest side) is called the hypotenuse, and is usually labeled c.
The two sides that meet at right angles are called the legs of the right triangle. The leg opposite <B is labeled b and the leg opposite <A is labeled a.

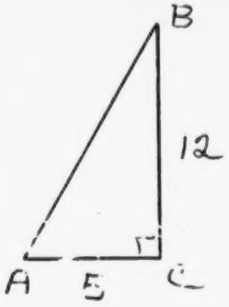
The Pythagorean Theorem

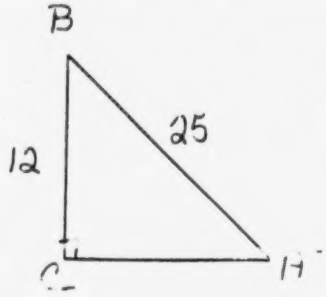
The sides of a right triangle are related to each other in a special way by the Pythagorean Theorem, named after a Greek philosopher named Pythagoras who first developed the formula.

> In a right triangle, the square of the length of the hypotenuse equals the sum of the squares of the lengths of the two sides. ($a^2 + b^2 = c^2$)

The Pythagorean Theorem can be used to find the length of the hypotenuse or leg of a right triangle. It can also be used to determine whether or not a certain triangle is a right triangle.

Find the missing sides of the right triangles.





Activity 2: Calculating diagonal lengths of rectangles

Equipment: Tape measure
Calculator

Statement of Problem: Drawing a diagonal across a rectangle gives two identical right triangles. In this activity, you measure the length and width of several rectangular objects. Then, you calculate the lengths of the diagonals with the Pythagorean Theorem and compare the calculated diagonal lengths to the measured diagonal lengths. In addition, you calculate the length of a room diagonal, from a corner at the ceiling all the way across the room to an opposite corner at the floor.

Procedure: Carry out steps a, b, and c (below) on each of the following rectangular objects.

-classroom door
-teacher's desk
-chalkboard
-classroom floor

a. Measure the width of the object. Record this measurement on a sheet of paper.

b. Measure the length of the object. Record this measurement on a sheet of paper.

c. Measure the diagonal of the object of the object. Record this measurement on a sheet of data paper.

Calculations:

a. Use the Pythagorean formula to calculate the length of the diagonal for each object. In the Pythagorean formula,

$$c^2 = a^2 + b^2$$

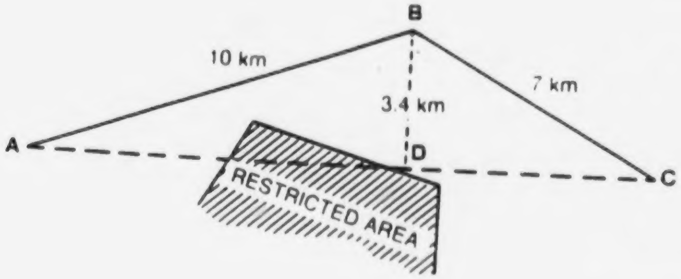
where a and b are the length and width, and c is the diagonal. Remember to take the square root to get the value of c.

b. Compare the calculated diagonal lengths to the measured diagonal lengths for each object.

c. Make appropriate measurements to determine the room diagonal (length, width, height). Make a sketch of the room and identify the room diagonal whose length is to be determined.

d. Use the appropriate measurements and the Pythagorean formula to calculate the room diagonal. How does the length of the diagonal compare with the length, width or height of the room?

EXERCISE: A plane is forced to travel the two-legged path shown below to avoid flying over a restricted area. Point B is 3.4 km from the straight path that could be take, if it weren't for the restriction. How much shorter is the direct route than the two-legged path?


B
10 km
7 km
3.4 km
A
D
C
RESTRICTED AREA

4

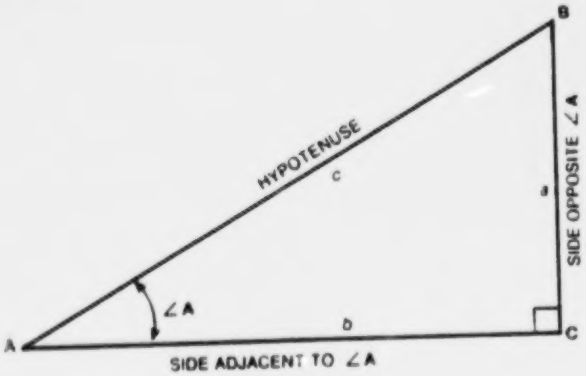
Trigonometric Ratios

There are other relationships in right triangles. This time we will look at ratios that are related to a specified angle of the right triangle.

$$\sin A = \frac{\text{length of opposite leg}}{\text{length of hypotenuse}}$$

$$\cos A = \frac{\text{length of adjacent leg}}{\text{length of hypotenuse}}$$

$$\tan A = \frac{\text{length of opposite leg}}{\text{length of adjacent leg}}$$



SOH-CAH-TOA

Given the following right triangle, find :

sin A =

cos A =

tan A =

We will now use our calculator to find trig ratios:

Be sure your calculator is in the degree mode. It should say DEG on the display. Enter the angle first, then press the appropriate trig key.

Find:

sin 30° =	tan 45° =
cos 75° =	sin 15° =
tan 34° =	cos 83° =

We can use the calculator to find the angle too. Enter the decimal, then press **2nd** and the appropriate trig key.

sin A = 0.8290	tan A = 3.4874
A =	A =
cos B = 0.8829	sin B = 0.3090
B =	B =

Now let's use the definitions of the trig ratios and our calculator to solve triangles.

<C = 90°, <A = 48°, c = 12 Find a

<C = 90°, <B = 50°, a = 15 Find b

<C = 90°, a = 22, b = 25, find <A

<C = 90°, b = 14, c = 20, find <B

EXERCISE: A single-engined airplane loses operation of its only engine. It is able to maintain a glide path that makes an angle of 18° with the ground. If the engine failure occurs at an altitude of 6000 ft above the ground, what is the maximum horizontal distance that it will be able to glide before crashing?

EXERCISE: A jet is able to maintain a speed of 600 km/hr while climbing at an angle of 30°.

a. The speed of the plane is actually a vector -- a speed at an angle. Part of the speed is spent horizontally, and part is spent vertically. Draw a right triangle that shows these two components as they relate to the actual speed (hypotenuse) of 600 km/hr.

b. Determine the value of the horizontal and vertical components (find the legs) of the jet's velocity.

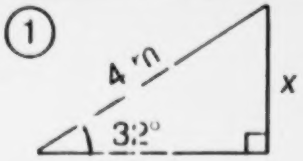
c. Use the vertical component of the velocity to find how long it will take the jet to reach an altitude of 10 km (that is, 10,000 m).

OBJECTIVE 5-c: To use trigonometric ratios to find lengths of sides of right triangles.

What Do They Call the Big Grass Field on an Orbiting Satellite?

For the first eight exercises, find the length x. For the remaining exercises, find the length needed to solve the problem. Round each answer to the nearest tenth. Cross out each box that contains a correct answer. When you finish, write the letters from the remaining boxes in the spaces at the bottom of the page.

①



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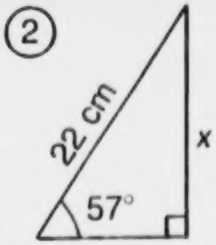

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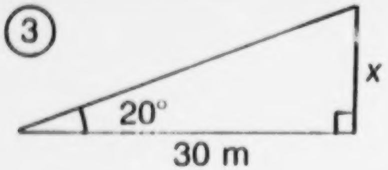

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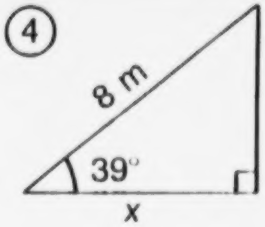

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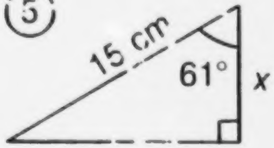

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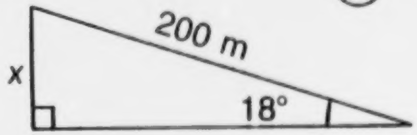

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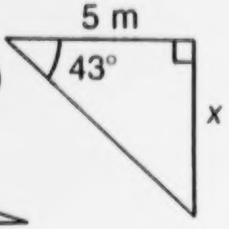

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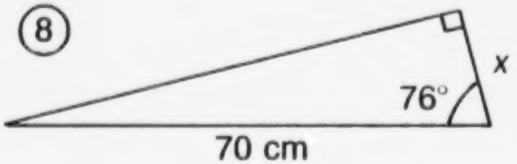
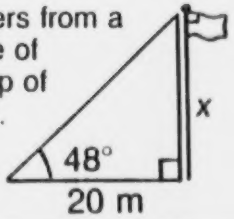
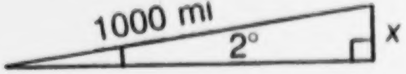


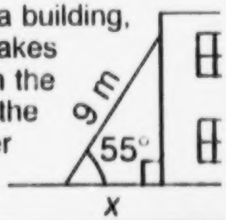
⑨ At a point 20 meters from a flagpole the angle of elevation of the top of the flagpole is 48°. How tall is the flagpole?



⑩ If a rocket flies 2° off course for 1000 miles, how far from the correct path will the rocket be?



⑪ As it leans against a building, a 9-meter ladder makes an angle of 55° with the ground. How far is the bottom of the ladder from the base of the building?



TH 4.7 m	AP 5.4 m	ET 5.2 m	E 2.1 m	AR 23.5 m	UN 6.2 m	A 22.2 m	KI 28.7 mi	SS 61.8 m
RU 18.5 cm	NS 3.2 m	TO 7.3 cm	P 63.6 m	UP 34.9 mi	A 15.3 cm	KY 10.9 m	NI 16.9 cm	CE 17.1 cm

• DAFFYNITION DECODER •

EUROPE:

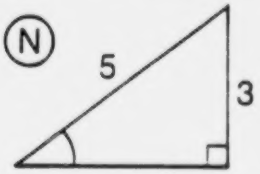
30°	42°	21°	24°	74°	2°	21°	24°	37°	49°	2°	42°	17°	32°	5°	2°

UNDERGROUND GARAGE:

46°	5°	9°	9°	28°	2°	42°	7°	46°	5°	9°	9°	7°	51°	5°	24°	68°	34°	2°

TO DECODE THE TWO DAFFYNITIONS ABOVE: For the first nine exercises, find the measure of the angle indicated. For the remaining exercises, find the angle measure needed to solve the problem. Round to the nearest degree. Each time the answer appears in the code, write the letter of the exercise below it.

Ⓝ



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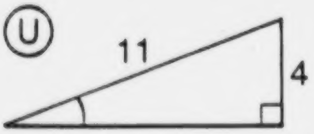

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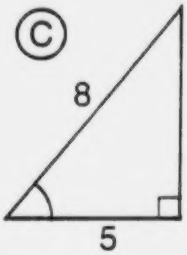

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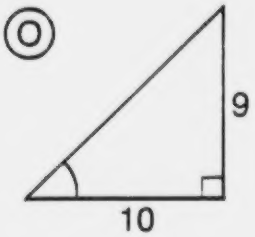

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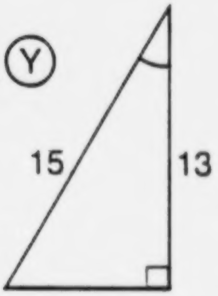

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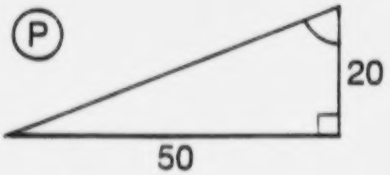

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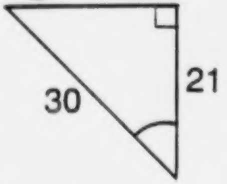

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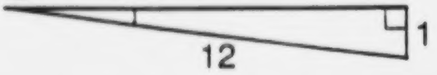

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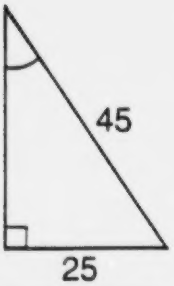
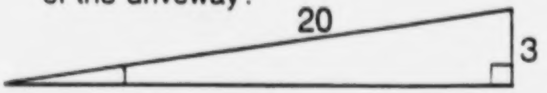
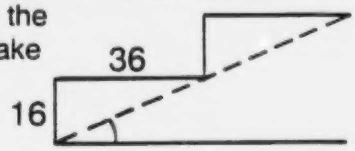


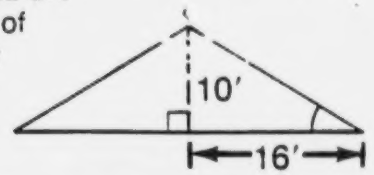
Ⓛ A driveway is built on an incline so that it rises 3 m over a distance of 20 m. What is the angle of elevation of the driveway?



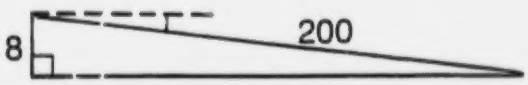
Ⓡ Each step of a stairway rises 16 cm for a tread width of 36 cm. What angle does the stairway make with the floor?



Ⓑ A roof is constructed as shown in the diagram. Find the pitch (angle of elevation) of the roof



Ⓣ A train decreases its altitude by 8 m when traveling along 200 m of track. Find the angle of depression of the track.



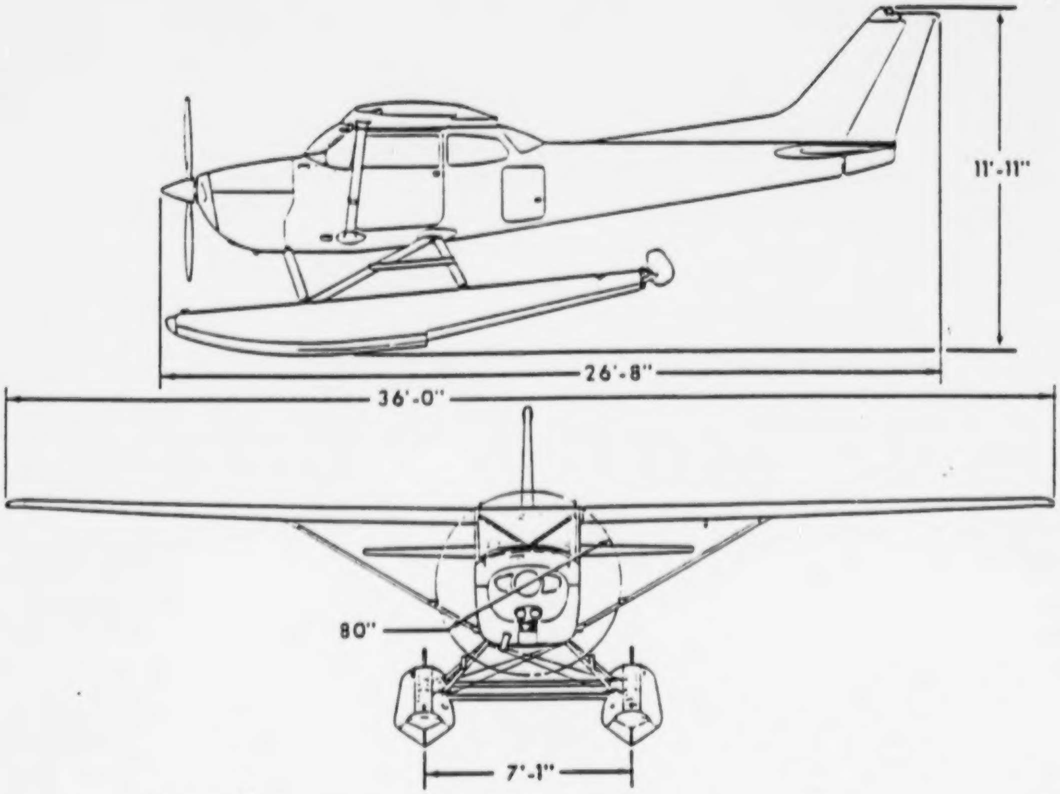
OBJECTIVE 5-d: To use trigonometric ratios to find measures of angles of right triangles.

TAKEOFF DISTANCE

Solve the following problem using the chart on the next page. Though you do not use trig to use this problem, someone did in order to make this chart. Your problem is to read the chart correctly.

You are on a lake ready to take off. You have a pressure altitude of 2000 feet, have 3200 feet of clear water, but the lake is rimmed by 50 foot pines. If the temperature is 24°C, would you be able to take off? Defend your answer.

10



TAKEOFF DISTANCE

MAXIMUM PERFORMANCE

CONDITIONS:
Flaps 10°
Full Throttle
Zero Wind

NOTE:
Decrease distances 10% for each 9 knots headwind.

WEIGHT LBS	TAKEOFF SPEED KIAS		PRESS ALT FT	0°C		10°C		20°C		30°C		40°C	
	LIFT OFF	AT 50 FT		WATER RUN	TOTAL TO CLEAR 50 FT OBS	WATER RUN	TOTAL TO CLEAR 50 FT OBS	WATER RUN	TOTAL TO CLEAR 50 FT OBS	WATER RUN	TOTAL TO CLEAR 50 FT OBS	WATER RUN	TOTAL TO CLEAR 50 FT OBS
2220	47	53	S.L.	1185	1870	1325	2060	1480	2270	1660	2505	1870	2780
			1000	1380	2140	1550	2365	1750	2625	1975	2920	2245	3265
			2000	1625	2470	1840	2750	2095	3075	2345	3455	2750	3905
			3000	1945	2890	2225	3245	2555	3665	2960	4185	3460	4770
			4000	2365	3430	2735	3900	3195	4460	3775	5150	4520	6015

Figure 6. Takeoff Distance

Equipment

Flat square
String (100 ft)
Directional compass
Calculator

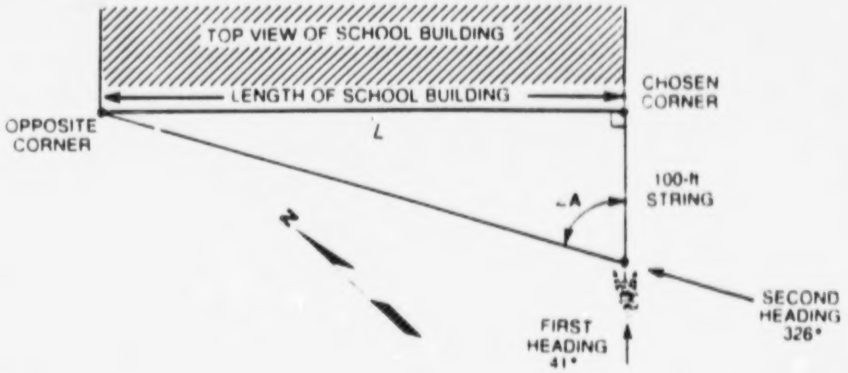
Statement of Problem

The ratios of the sides of a right triangle are useful in estimating and measuring distances. In this activity, you use the tangent ratio to measure the length of the school building.

Procedure

a. Choose a corner of the school building. See drawing below. Stretch the 100-ft string from the corner of the school building, so that it is perpendicular to the wall. Use the flat square to help give you a 90° angle. Adjust the end of the string until the wall and string form as near a 90° angle as you can measure.

b. Go to the end of the string away from the school building. Use the directional compass and find the compass heading from the end of the string to the chosen corner AND the opposite corner of the building on the wall perpendicular to the string. See the drawing below. Record the two compass headings on a sheet of data paper.



Calculations

a. Subtract the two compass headings. If the difference in the compass headings is less than 90°, this difference is the measure of ∠A in the drawing. If the difference is greater than 90°, subtract the difference from 360° to get the measure of the angle. For example, with reference to the drawing, suppose the compass headings were 41° and 326°. This gives a difference of $326° - 41° = 285°$. Since 285° is greater than 90°, subtract 285° from 360° to get 75°. The measure of ∠A is 75°.

b. Use your calculator and the formula below to calculate the distance between the two corners.

$$\tan A = \frac{\text{opp}}{\text{adj}} = \frac{\text{Length of school building}}{100 \text{ ft}}$$

$$\tan A = \frac{L}{100 \text{ ft}}$$

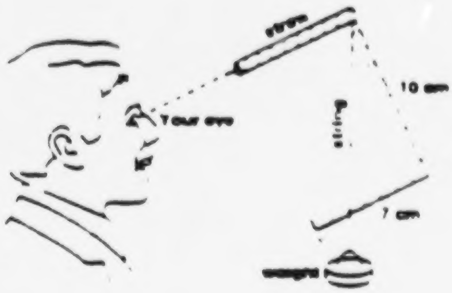
$$\therefore L = 100 \tan A$$

c. Describe how you could use this method to measure the distance between two points on opposite sides of the Grand Canyon.

Making and using a Hypsometer

A hypsometer is a device that can be used to measure the height of an object. To construct your own hypsometer, you will need a rectangular piece of heavy cardboard that is at least 7 cm by 10 cm, a straw, transparent tape, a string about 20 cm long, and a small weight that can be attached to the string.

Mark off 1-cm increments along one short side and one long side of the cardboard. Tape the straw to the other short side. Then attach the weight to one end of the string, and attach the other end of the string to one corner of the cardboard, as shown in the figure below. The diagram below shows how your hypsometer should look.



To use the hypsometer, you will need to measure the distance from the base of the object whose height you are finding to where you stand when you sue the hypsometer.

Sight the top of the object through the straw. Note where the free-hanging string crosses the bottom scale. Then use similar triangles to find the height of the object. Draw a diagram to help you.

USE YOUR HYPSOMETER TO FIND THE HEIGHT OF EACH OF THE FOLLOWING.

1. flagpole

2. tree

3. height of school building

4. top of utility pole (light pole)

SUMMARY

This unit introduces new ideas, definition, and relationships that help you solve problems about right triangle. Many on the job problems require that you find the lengths of the sides of a right triangle. Sometimes distances are too difficult to measure, but you can calculate them using the properties of right triangles.

The Pythagorean Theorem gives you a way to find the sides of right triangles. If you know any two sides of a right triangle, you can always calculate the third side by using the formula $a^2 + b^2 = c^2$. The variables a an b stand for the lengths of the two legs of the triangle, and c stands for the length of the hypotenuse.

The hypotenuse --the side opposite the right angle -- is always the longest side of the right triangle. The Pythagorean formula says that the square of the length of the hypotenuse is equal to the sum of the squares of the lengths of the two legs.

Trigonometry defines three special ratios for an angle in a right triangle. They are sine, cosine, and tangent (SOH-CAH-TOA). These ratios can be used to solve a variety of problems in many program areas (aviation, electronics, machine shop, auto mechanics, construction, etc).

APPLIED MATH

WEEK THREE

PERCENT

Introduction

If you looked at a newspaper or magazine, listened to the radio, or watched TV today, you almost certainly came across the word "percent" or the symbol %. Every time you buy a hamburger or gasoline, you work with decimal numbers. When you share a pizza, or split the cost of a tape with your sister or brother, you work with fractions. In the health occupations area employees work with percent daily.

Fractions, decimals and percents are different ways to name numbers. These numbers look quite different. Do they have different values?

1/2	50%	0.5	one-half

Percent means how many parts in each hundred parts. For example, 43 percent (43%) means that there are 43 parts in each hundred parts.

To change a percent to a decimal, remove the percent sign and move the decimal point two places to the left (divide by 100). For example, for the value 39%, remove the percent sign and move the decimal point two places to the left. The answer is 0.39.

To change a decimal to a percent, move the decimal point two places to the right (multiply by 100) and add the % sign. For example, for the decimal 0.78, move the decimal point two places to the right to get 78. Then add the % sign to the right of the number to get 78%.

To change a fraction to a percent, first change it to a decimal by dividing the numerator (top) by the denominator (bottom). Then you can change it to a percent by using the above rules.

EXERCISE: Kevin has determined that he takes in about 3000 calories per day. Kevin eats 450 calories for breakfast, 1200 calories for lunch, and 300 calories during afternoon snacks.

a. What fraction of his daily total intake does he receive at supper?

b. What percentage is this?

c. At what meal does Kevin consume the largest fraction of his calories?

EXERCISE: The body is able to obtain 4 calories of heat energy from each gram of glucose. A patient receives 500 grams o 10% glucose solution.

a. Express the glucose percentage as a decimal.

b. How many grams of glucose does the patient get out of the 500 grams of solution?

c. How many calories does the patient receive from this glucose?

EXERCISE: The label on the vitamin container says that each capsule provides 125% of the recommended daily allowance (RDA) of vitamin C. The RDA of vitamin C is 30 milligrams.

a. Express the percentage given as a decimal.

b. How many milligrams of vitamin C are in each capsule?

EXERCISE: A state requires a score of at least 70% on its certification exam for a certain health profession. In other words, you must correctly answer at least 70% of the questions you attempt.

a. If you attempt 350 questions, and miss 28 of them, what fraction of the attempted questions have you missed?

b. What percentage have you missed?

c. What percentage have you answered correctly?

d. What is the most you could have missed and still qualified for certification?

Activity 3: Rating popcorn

Equipment

Hot air popcorn popper
Large bowl
Three brands of popcorn
Calculator

Given

One way to rate popcorn is to determine which brand ends up with the fewest unpopped kernels.

Find

The best and worst of three brands of popcorn.

Procedure

a. Count out 100 kernels (or some such reasonable number) of one of the brands of popcorn. Pop the 100 kernels.

b. When the popping is complete, count the popped kernels. Count the unpopped kernels. Do they add to 100?

c. What fraction of the popcorn is popped? What fraction of the popcorn is unpopped?

d. What percent of the popcorn is popped? What percent of the popcorn is unpopped?

e. Repeat Steps a. through d. for the other two brands.

f. Which brand of popcorn had the smallest percent of unpopped kernels? Which brand had the largest percent of unpopped kernels?

g. Did your rating of the popcorn brands agree with the other groups in you class? Did your percentages agree with the other groups in your class? Is this a fair way to rate popcorn?

MEASURING IN ENGLISH AND METRIC UNITS

Introduction

In almost every job, workers need answers to questions such as these:

How long or how far is it? How long is the board? How wide is the paper? How far is it to the next town?

How much is there? How much weight? How much liquid? How much pressure? How much voltage? How much temperature?

To find answers to these questions, you measure -- length, distance, weight, area, volume, pressure, voltage, temperature, and so on. You can use a variety of instruments to measure different quantities.

There are two widespread systems of measurement for common quantities such as length, weight, and capacity. You are probably most familiar with the English system of measurement. It's the most common system used in the United States. In it, length is measure in inches, feet, yards, miles, etc. Weight is measure in ounces or pounds, and capacity is measured in cups, quarts, or gallons. In most other countries in the world, people measure with the metric system. In it, length is measured in meters, weight is measured in grams, and capacity is measured in liters.

Because the United States does more and more business with other countries, the metric system in increasingly important to us. For example an automobile mechanic now keeps two sets of tools -- one for foreign made cars and new American cars, and one for older American cars that were made with English measurements.

Sports events, such as track and field, swimming, and diving now often use metric lengths instead of feet, yards and miles.

Using a unit conversion ratio

Sometimes you need to convert from one unit of measure to another similar one. For example, how many inches are in two feet? How many yards are in 1320 feet?

Two simple facts of mathematics give you a powerful way to change from one unit of measure to another similar one.

First, you know that any number divided by itself equals 1:

6/6 = 1   3.91/3.91 = 1   5201/5201 = 1

It is easy to see that each of these fractions equals 1 because the numerator and denominator are the same. However, any quantity divided by itself equals 1 even if the numerator and denominator are written differently. Look at the following ratios:

1 ft / 12 in = 1   16 oz / 1 lb = 1   4 c / 1 qt = 1

In each case, the numerator and denominator of the ratio name the same amount. In each case, the ratio is equal to one. Let's refer to such fractions -- or ratios -- as unit conversion ratios. As we will see, they are useful in changing -- or converting -- from one unit of measure to another.

The second mathematical fact that helps you change from one unit of measure to another is this : Multiplying (or dividing) by 1 does not change the value of a number:

$5 \times 1 = 5$ $\qquad 2.78 \times 1 = 2.78$ $\qquad 1/2 \times 1 = 1/2$

EXAMPLE:

Convert 24 inches to feet. Use the conversion factor 1 ft / 12 in.

$$24 \text{ in} \times \frac{1 \text{ foot}}{12 \text{ inches}} = \left(\frac{24 \times 1}{12}\right)\left(\frac{\cancel{\text{inches}} \times \text{foot}}{\cancel{\text{inches}}}\right) = 2 \text{ feet}$$

The original units (inches) divide out -- since inches/inches = 1 -- and what is left is the desired answer in the new units -- 2 feet.

How do you pick the unit conversion ratio you need to convert form one unit of measure to another? To convert from the unit you have to the unit you want, the unit conversion ratio is always written as:

$$\frac{\textbf{new units} \text{ (the ones you want to change to)}}{\textbf{old units} \text{ (the ones you have to start with)}}$$

EXAMPLE: How many cups are there in one gallon?

NOTE: 4 qt / 1 gal 4c / 1 qt

$$1 \text{ gal} = \frac{1 \text{ gal}}{1} \times \frac{4 \text{ qt}}{1\text{gal}} \times \frac{4 \text{ c}}{1 \text{ qt}} = \left(\frac{1 \times 4 \times 4}{1 \times 1 \times 1}\right)\left(\frac{\cancel{\text{gal}} \times \cancel{\text{qt}} \times \text{c}}{\cancel{\text{gal}} \times \cancel{\text{qt}}}\right) = 16 \text{ c}$$

This same system is used to convert in the metric system and back and forth from the English to metric system. TRY THESE:

5.7 yd = ? inches

7 km = ? meters

27 inches = ? cm

50 lbs = ? kg

EXERCISE: The doctor has ordered a liter of D_5W (dextrose 5% and water). The standard sizes for D_5W are 1000 cc, 500 cc, and 250 cc. A "cc" is essentially the same as a milliliter. Which size (in cc) has the doctor ordered?

EXERCISE: Cliff is recovering from surgery, but the doctor has released him to return to light duties at his job as custodian at the school. The doctor recommended that he lift no more than 20 pounds for the next few weeks.

a. About how much will the five-gallon bucket of soapy water that he uses to clean the floors weigh? Should Cliff lift it? A gallon of water weighs about 8.3 pounds.

b. A carton of powdered soap is labeled to weigh 5 kilograms. Is it safe for Cliff to lift the box of soap?

EXERCISE: A culture medium is to be grown at a temperature of 35°C. Will it have to be placed in a warming oven, a refrigerator, or will room temperature be satisfactory? (See dual-scale thermometer in the conversion charts)

EXERCISE: A commercial cold medicine indicates that an adult should receive one-half fluid ounce at bedtime. An adult patient phones the pharmacy where you work and says that he only has a small medicine cup labeled in milliliters. How many milliliters should you tell him to measure out for the correct dosage?

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EXERCISE: You need to administer gamma globulin injections to the staff who have been exposed to hepatitis. The prescribed dosage is 0.05 cc per kilogram of body weight, rounded to the nearest 0.1 cc. The staff's body weights are: Dr. Stone, 138 pounds, Judy 119 pounds, Maria 125 pounds, and Rick 210 pounds.

a. What is each of the staff's body weight expressed in kilograms? Round your answer to the nearest kilogram.

b. How much gamma globulin should each of the staff receive? (Remember to round to the nearest 0.1 cc.)

Conversion Tables

The conversion tables on the next few pages can help you to convert between most of the units you are likely to encounter. Set up a unit conversion ratio, as shown previously on page 5.

1. Length

To convert from meters to inches, for example, find the row labeled "1 meter" and the column labeled "in." The conversion factor is 39.37. Thus, 1 meter = 39.37 in.

	cm	m	km	in	ft	yd	mi
1 centimeter	1	0.01	10^{-5}	0.3937	3.281×10^{-2}	1.094×10^{-2}	6.214×10^{-6}
1 meter	100	1	10^{-3}	39.37	3.281	1.094	6.214×10^{-4}
1 kilometer	10^5	1000	1	3.937×10^4	3281	1094	0.6214
1 inch	2.54	0.0254	2.54×10^{-5}	1	0.0833	0.0278	1.578×10^{-5}
1 foot	30.48	0.3048	3.048×10^{-4}	12	1	0.3333	1.894×10^{-4}
1 yard	91.44	0.9144	9.144×10^{-4}	36	3	1	5.682×10^{-4}
1 mile	1.6093×10^5	1609.3	1.6093	6.336×10^4	5280	1760	1

2. Area

	cm^2	m^2	in^2	ft^2	A	mi^2
1 square centimeter	1	10^{-4}	0.1550	1.076×10	2.471×10^{-8}	3.861×10^{-11}
square meter	10^4	1	1550	10.76	2.471×10^{-4}	3.861×10^{-7}
1 square inch	6.452	6.452×10^{-4}	1	6.944×10	1.594×10^{-7}	2.491×10^{-10}
1 square foot	929.0	0.09290	144	1	2.296×10^{-5}	3.587×10^{-8}
1 acre	4.047×10	4047	6.273×10^6	43.560	1	1.563×10^{-3}
1 square mile	2.590×10^{10}	2.590×10^6	4.007×10^9	2.788×10^7	640	1

Note: The use of "scientific notation" is discussed in Unit 12 of Applied Mathematics. Briefly, the number 3.281×10^{-2} is equivalent to 0.03281, and the number 3.937×10^4 is equivalent to 39,370. If you have difficulty understanding this, please consult your teacher.

3. Volume (capacity)

	cm³	m³	in³	ft³	ℓ	oz	gal
1 cubic centimeter	1	10^{-6}	0.06102	3.531×10^{-5}	1.000×10^{-3}	0.03381	2.642×10^{-4}
1 cubic meter	10^{6}	1	6.102×10^{4}	35.31	1000	3.381×10^{4}	264.2
1 cubic inch	16.39	1.639×10^{-5}	1	5.787×10^{-4}	0.01639	0.5541	4.329×10^{-3}
1 cubic foot	2.832×10^{4}	0.02832	1728	1	28.32	957.5	7.480
1 liter	1000	1.000×10^{-3}	61.03	0.03532	1	33.81	0.2642
1 ounce	29.57	2.957×10^{-5}	1.805	1.044×10^{-3}	0.02957	1	7.813×10^{-3}
1 gallon	3785	3.785×10^{-3}	231	0.1337	3.785	128	1

1 gallon = 4 quarts (qt) = 8 pints (pt) = 16 cups (c)
1 cup (c) = 8 ounces (oz) = 16 tablespoons (tbsp) = 48 teaspoons (tsp)

4. Mass/weight

	g	kg	oz	lb	ton*
1 gram	1	10^{-3}	0.03527	2.205×10^{-3}	1.102×10^{-6}
1 kilogram	10^{3}	1	35.27	2.205	1.102×10^{-3}
1 ounce	28.35	0.02835	1	0.0625	3.125×10^{-5}
1 pound	453.6	0.4536	16	1	0.0005
1 ton*	9.072×10^{5}	907.2	3.2×10^{4}	2000	1

*short ton

Note: The use of "scientific notation" is discussed in Unit 12 of Applied Mathematics. Briefly, the number 3.281×10^{-2} is equivalent to 0.03281, and the number 3.937×10^{4} is equivalent to 39,370. If you have difficulty understanding this, please consult your teacher.

5. Angle

	′	°	rad	rev
1 minute	1	0.01667	2.909×10^{-4}	4.630×10^{-5}
1 degree	60	1	0.01745	2.778×10^{-3}
1 radian	3438	57.30	1	0.1592
1 revolution	2.16×10^{4}	360	6.283	1

6 Time

	sec	min	h	d*	y*
1 second	1	0.01667	2.778×10^{-4}	1.157×10^{-5}	3.169×10^{-8}
1 minute	60	1	0.01667	6.944×10^{-4}	1.901×10^{-6}
1 hour	3600	60	1	0.04167	1.141×10^{-4}
1 day*	8.640×10^{4}	1440	24	1	2.738×10^{-3}
1 year*	3.156×10^{7}	5.259×10^{5}	8766	365.3	1

*sidereal

NOTE: The use of "scientific notation" is discussed in Unit 12 of Applied Mathematics. Briefly, the number 3.281×10^{-2} is equivalent to 0.03281, and the number 3.937×10^{4} is equivalent to 39,370. If you have difficulty understanding this, please consult your teacher.

Temperature

The dual-scale thermometer shown here can be used to obtain the equivalent temperatures for the Fahrenheit and Celsius scales. For example, 20°C is shown below to be equal to 68°F.

The two scales are also related by the formulas given below.

a. $°F = \frac{9}{5}\,°C + 32°$

For example, for 20°C,

$$°F = \frac{9}{5}(20°) + 32°$$

$$°F = 36° + 32°$$

$$°F = 68°$$

So, 20°C is equal to 68°F.

b. $°C = \frac{5}{9}(°F - 32°)$

For example, for 68°F,

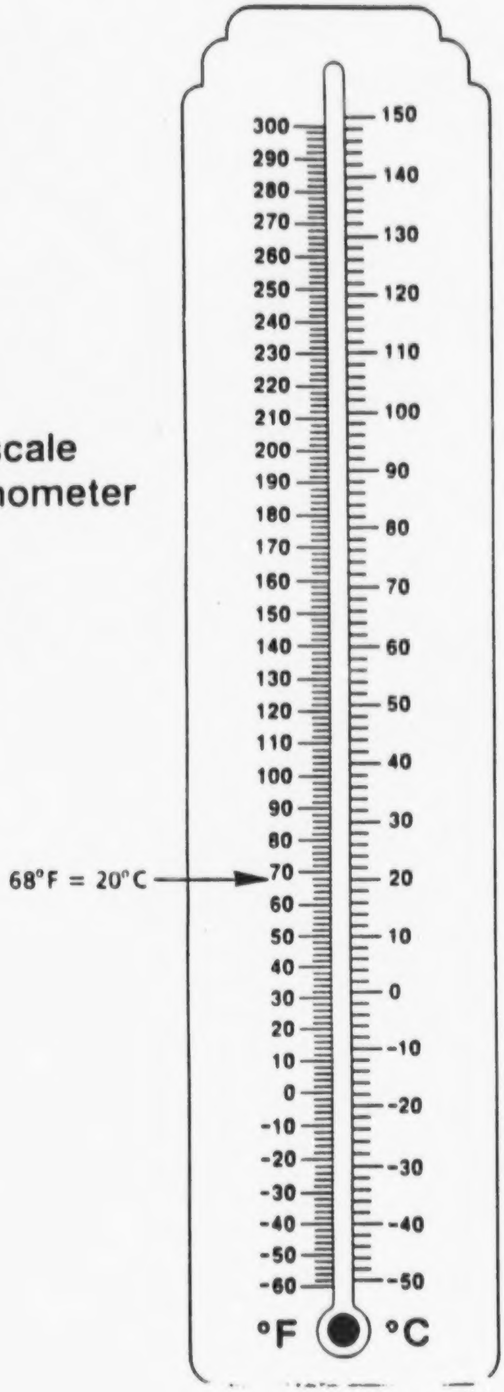
$$°C = \frac{5}{9}(68° - 32°)$$

$$°C = \frac{5}{9}(36°)$$

$$°C = 20°$$

So, 68°F is equal to 20°C.

Dual-scale Thermometer


300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
68°F = 20°C
°F
°C

Activity 2: Measuring volumes

Equipment

Empty 2-liter soft drink bottle
Six empty 12-ounce soft drink cans
Measuring cup marked in ounces (1-cup or 2-cup capacity)
Funnel
Package of 8-ounce paper cups
Ruler
Water supply
Masking tape
Pencil and paper
Calculator

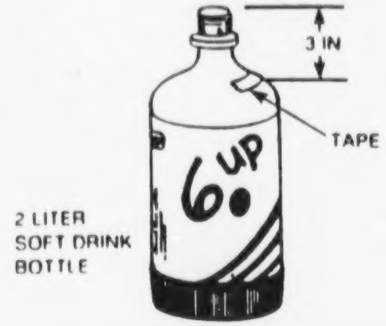
Statement of Problem

In this activity you will compare the cost of a consumer product that is sold by a metric volume to the cost of the same product sold by an English volume. The price of a 2-liter soft drink is $1.49. The price of a six-pack of 12-ounce soft drinks is $1.89.

Procedure

a. Calculate the cost per ounce of the soft drink in the six-pack of 12-ounce cans sold for $1.89.

b. Measure 3 inches down from the top of the 2-liter soft drink bottle (see drawing after this step). Put a piece of masking tape on the bottle so the bottom of the tape marks the 3-inch distance. Put the funnel in the bottleneck. Fill the measuring cup with water to the 8-ounce (or 16-ounce) mark and pour it into the bottle. Write a tally mark on a sheet of paper to indicate "one cup." Repeat this process until the water level reaches the bottom of the tape. Mark a tally mark for the last cup and, if water is left in the cup, write the number of ounces left in the cup. Count the number of tally marks and multiply by the 8 ounces (or 16 ounces). Subtract from this number the number of ounces of water left in the measuring cup. This is the volume of the 2-liter bottle in ounces. Save the filled bottle for Part e.



c. Calculate the cost per ounce of the soft drink in the 2-liter bottle sold for $1.49.

d. If an average serving size is 8 ounces, how many servings will each package of soft drink give? Which package of soft drink has the lower cost per ounce? Which is the better buy? Why do you think this is a better choice than the other one?

e. Fill the empty 12-ounce cans with water. Determine the number of 8-ounce cups you can fill from the six 12-ounce cans. How does this compare to the number of 8-ounce servings you calculated in Part d? Determine the number of 8-ounce cups you can fill from the 2-liter bottle you filled in Part b. How does this number compare to the number of 8-ounce servings you calculated in Part d?

Activity 3: Measuring areas

Equipment

Yardstick or tape measure marked in feet
Meter stick or tape measure marked in meters
Pencil and paper
Accu-line™
Calculator

Statement of problem

The area of a rectangle is the product of its length and width. In this activity, you will measure the length and width of your classroom in feet and in meters. Then you will determine the area in square feet and in square meters. Finally, you will calculate conversion factors from square feet to square meters and from square meters to square feet.

Procedure

a. Measure the length and width of your classroom in feet. Determine the area of the room in square feet. Write your measurements and the calculated area on your paper.

b. Measure the length and width of your classroom in meters. Determine the area of the room in square meters. Write your measurements and the calculated area on your paper.

c. Divide your length measurement in feet by your length measurement in meters. This is a conversion factor from meters to feet. Divide your width measurement in feet by your width measurement in meters. This is also a conversion factor from meters to feet. Compare these two conversion factors. Are they the same? Write these conversion factors on your paper. Compare these conversion factors to the conversion factor from meters to feet given in Figure 3-7 of your text.

d. Let 1 inch equal 5 feet and make a scale drawing of the classroom with the Accu-Line™. Label the drawing with the measurements in feet and meters. Write the area in square feet and square meters on the drawing.

e. Divide your length measurement in meters by your length measurement in feet. This is a conversion factor from feet to meters. Divide your width measurement in meters by your width measurement in feet. This is also a conversion factor from feet to meters. Compare these two conversion factors. Are they the same? Write these conversion factors on your paper. Compare these conversion factors to the conversion factor from feet to meters given in Figure 3-7 of your text.

f. Divide your area measurement in square meters by your area measurement in square feet. This is a conversion factor from square feet to square meters. Divide your area measurement in square feet by your area measurement in square meters. This is a conversion factor from square meters to square feet. Write these conversion factors on your paper.

g. Compare your conversion factor from *square feet to square meters* with your conversion factor from *feet to meters*. Are they the same? If they are not the same, why do you think they are different. Compare the conversion factor from *square meters to square feet* with the conversion factor from *meters to feet*? Are they the same? Why?

USING SCIENTIFIC NOTATION

Introduction

What size numbers do you work with most often? You may seldom use numbers over 10,000, and most of the time you probably use numbers that are between 0.1 and 100. You may read in newspapers about budgets in the million -- or even billions and trillions of dollars. And you may hear of measurements made to ten thousandths of an inch. But aside from such occasions, you may not often write or read large numbers.

Nevertheless, many people do use very large and very small numbers every day on the job. For example, people who work in the space industry, the world bank or national defense often use large numbers. Persons working in a biology lab or center for disease control may work with human cells and viruses -- and use very small numbers. Astronomers use telescopes to study stars and planets that are great distances from the earth. And biologists use microscopes to examine objects much smaller than you can see with the naked eye.

Let's look at other examples of very large and very small numbers:

An ounce of gold contains approximately
    86,700,000,000,000,000,000,000 atoms.
One atom of gold has a mass of
    0.000000000000000000000327 grams.
The average volume of an atom of gold is
    0.00000000000000000000001695 cubic centimeters.
The weight of the earth is about
    6,600,000,000,000,000,000,000 tons.
A single human red blood cell is about 0.000007 meters in diameter.
There are about 5,000,000 human red blood cells in one cubic millimeter
    of blood.

WRITING NUMBERS IN SCIENTIFIC NOTATION

So far you've learned what positive powers of ten—such as 10^4 or 10^6—mean, and what negative powers of ten—such as 10^{-3} or 10^{-5}—mean. You've also learned how to write numbers like 86,700,000,000,000,000,000,000 and 0.000007 in power-of-ten notation—as 867×10^{22} and 7×10^{-6}, respectively. The first of these is not yet in scientific notation; the second one is. Let's now look closely at numbers in *scientific notation*.

Numbers in scientific notation

A number is written in scientific notation when it is written in this way: **a number between one and ten multiplied by a power of ten.**

Look again at the number 867×10^{20}. Is this number written in scientific notation? The number 867 is multiplied by a power of ten, but 867 is not a number between one and ten. This means that 867×10^{20} is not written in scientific notation.

To write this number in scientific notation, you must begin with a number that is between one and ten. How can you write 867×10^{20} in a form that begins with a number between one and ten?

To write 867 in a different way, you can use the fact that **multiplying a number by ten is the same as moving the decimal point one place to the right.** This fact suggests that you can rewrite 867 in this way: move the decimal point to the *left* to make the number *smaller* and, at the same time, multiply the number by ten to make the number *larger*. In this way you can rewrite a number without changing its value.

Thus

$$86.7 \times 10 = 867$$

But 86.7 is still not a number between one and ten.

Move the decimal to the left one more place to make the number still smaller, and multiply one more time by ten to keep the value the same. This gives

$$867 = 8.67 \times 10 \times 10$$

$$\text{or } 8.67 \times 10^2$$

Since 8.67 is a number between one and ten, you are now ready to write the original number (86,700,000,000,000,000,000,000) in scientific notation. Putting it all together:

$$86{,}700{,}000{,}000{,}000{,}000{,}000{,}000 = 867 \times 10^{20} = 8.67 \times 10^2 \times 10^{20}$$

Multiplying by 10 twice, and then by 10 twenty times as in $10^2 \times 10^{20}$, is the same as multiplying 10 by itself 22 times. This means that $10^2 \times 10^{20} = 10^{22}$.

A shorter way to write this number is

$$8.67 \times 10^{22}$$

Is 8.67×10^{22} written in scientific notation? Is it written as a **number between one and ten multiplied by a power of ten?** Since 8.67 is a number between one and ten, and 10^{22} is a power of ten, 8.67×10^{22} is written in scientific notation.

How to write in scientific notation

Now let's look at a *general method* for writing numbers in scientific notation. Example 3 shows how to do this for small numbers. Example 4 shows how to do the same thing for large numbers.

Example 3:
Writing a small number in scientific notation

Let's examine the process by rewriting the number 0.000007 in scientific notation. Follow these steps:

First, write the number with a pointer ($_\wedge$) just to the *right of the first digit that is not zero*. This will be the new location of the decimal point.

$$0.000007_\wedge \text{ meters}$$

Second, use your pencil point to move from the pointer (the new decimal point) to the old decimal point, counting how many places you move, and in which direction (left or right).

$$0.000007_\wedge \text{ meters}$$

Notice that the new decimal point has made the number *larger* than the old number.

How many places did you move as you went from the new position (at the $\wedge$) to the old position of the decimal point? By moving the decimal you have made the number *larger* by six places. To balance this, you must make the number *smaller* by *dividing* it by ten six times.

Dividing by ten six times is the same as multiplying by $^1/_{10}$ six times. And multiplying by $^1/_{10}$ six times is the same as multiplying by 10^{-6} since

$$\frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} = 10^{-6}$$

So, you can replace $0.000007_\wedge$ meters by

$$7_\wedge \times 10^{-6} \text{ meters}$$

Third, replace the pointer with the new decimal point. The final result is:

$$7 \times 10^{-6} \text{ meters}$$

Finally, check to see if the new number is in scientific notation—a number between one and ten multiplied by a power of ten.

Here is a summary of those steps:

To convert from decimal form to scientific notation:

First, put a pointer (‸) to the *right of the first nonzero digit.*

Second, count the spaces as you move from the pointer (‸) to the old decimal point.

Third, replace the pointer (‸) with the new decimal point and multiply the number by 10 with an exponent that is the same as the number of places you moved. Moving *to the left* from the pointer (the new decimal point) gives a negative exponent; moving *to the right* from the pointer gives a *positive exponent.*

Fourth, check to see if the new number is in scientific notation—a number between one and ten multiplied by a power of ten.

Example 4: ***Rewriting a large number in scientific notation***

Try using the preceding steps to rewrite 270,000,000 molecules (the number of hemoglobin molecules in a single human red blood cell) in scientific notation.

First, put a pointer to the *right of the first nonzero digit.*

2‸70,000,000 molecules

Second, count the spaces as you move from the pointer (‸) to the old decimal point. (In this example you have to write in the *understood* decimal point—just to the right of the last zero.) As you move from the pointer (‸) to the decimal point, you count 8 spaces.

2‸70,000,000. molecules

Third, replace the pointer with the new decimal point and multiply the number by 10 with an exponent that is the same as the number of places you moved—in this case, 8. Remember, moving to the left gives a negative exponent; moving to the right gives a positive exponent. The final answer is

2.7×10^8 molecules

Fourth, check to see if the new number is in scientific notation—a number between one and ten times a power of ten.

How to rewrite in decimal form

Sometimes it is useful to rewrite numbers in the opposite direction, that is, from scientific notation to decimal form.

To convert from scientific notation to decimal form:

First, put a pointer in place of the original decimal point.

Second, move your pencil left or right from the pointer (left if the exponent is negative, right if the exponent is positive) as many places (adding zeros as needed) as the *absolute value* of the exponent.

Third, put a new decimal point where you stop moving.

Fourth, check to make sure that the new number is *equal* to the original number written in scientific notation.

Try applying these steps to rewrite this number in decimal form:

$$1.6022 \times 10^{-19} \text{ joules}$$

Example 5:
Changing from scientific notation to a decimal number

First, put a pointer in place of the original decimal point.

$$1_\wedge6022 \times 10^{-19} \text{ joules}$$

Second, move left from the pointer (since the exponent is negative) 19 places (19 is the absolute value of −19), adding zeros as needed.

$$0000000000000000001_\wedge6022 \text{ joules}$$

Third, put a new decimal point to the left of the last zero you wrote and add a zero in front of the decimal point to protect it from being accidentally omitted.

$$0.00000000000000000016022 \text{ joules}$$

Fourth, check to make sure that the number you write is *equal* to the original number written in scientific notation.

Whether you are rewriting numbers from decimal form to scientific notation, or from scientific notation to decimal form, remember these things:

- The pointer ($_\wedge$) goes just to the *right of the first nonzero digit.* If you are changing to scientific notation, this will be the new decimal point. If you are changing to the decimal form, the pointer will be at the original decimal point.

- You move from the pointer to the decimal point. (You move from the pointer to the old decimal point if you are changing to scientific notation; you move from the pointer to the new decimal point if you are changing to the decimal form.)
- A move to the right corresponds to a positive exponent; a move to the left corresponds to a negative exponent.
- You move as many places as the *absolute value* of the exponent.

Study Activity: Complete the following exercises to check your understanding of writing numbers in scientific notation—and changing from numbers in scientific notation to decimal form.

1. Write the following numbers in scientific notation.
   - a. 56.7
   - b. 56.7×10^2
   - c. 86,700
   - d. 0.00567
   - e. 10.1×10^{-6}
   - f. 0.00236×10^{-6}
2. Change the following numbers written in scientific notation to decimal form.
   - a. 5.67×10^1
   - b. 7.2×10^5
   - c. 1.23×10^{-4}
   - d. 8.67×10^{22}
   - e. 9.1×10^{-12}
   - f. 1.02×10^{-1}

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USING SCIENTIFIC NOTATION WITH YOUR CALCULATOR

Now that you can write numbers in scientific notation, you can use your calculator to work problems that have numbers with many zeros.

Entering numbers in scientific notation

Study Activity: Follow these steps to enter 1.6022×10^{-19} joules in your calculator.

First, enter the first number (the one between one and ten).

Enter 1.6022

Second, tell the calculator that you are about to enter an exponent by pressing the key labeled EE (which stands for Enter Exponent).

Press the EE key

Third, enter the exponent of ten—in this case, the number 19.

Enter 19
Press the +/– key to make the exponent negative.

Look at the display of your calculator to see how the calculator shows the number 1.6022×10^{-19} in the window.

To enter a number in scientific notation in the calculator:

First, enter the first number (the one between one and ten).

Second, press the key labeled EE.

Third, enter the exponent of ten and, if necessary, press the +/– key to make the exponent negative.

Limitations on working problems with the calculator

Now you are going to enter some numbers to see what your calculator can handle.

2c

Study Activity:

Begin with the problem that started this unit. Calculate the number of atoms in 3.45 ounces of gold. There are

86,700,000,000,000,000,000,000 atoms in one ounce of gold. Begin by converting 86,700,000,000,000,000,000,000 atoms to scientific notation.

8‸6,700,000,000,000,000,000,000. atoms per ounce

is the same as 8.67×10^{22} atoms per ounce

Then, enter this number into your calculator.

Enter 8.67
Press the EE key
Enter 22

Now multiply this number by 3.45 ounces.

Press the × key
Enter 3.45
Press the = key

Read the answer in the display window and write it as a number in scientific notation.

2.99115×10^{23} atoms

You can enter a number using the EE (Enter Exponent) key even if the number is not in scientific notation. However, many calculators will convert the number to scientific notation as soon as you start to perform an operation (such as = or × or ÷). The next activity shows this.

Study Activity:

Enter 2456×10^{80} in your calculator.

Enter 2456
Press the EE key
Enter 80

The display window shows *2456 80* which is not in scientific notation since 2456 is not a number between one and ten.

Press the = key

What has changed in the display window? With many calculators, the display window changes to show *2.456 83* because the calculator rewrites the number in scientific notation as soon as you press a key for any operation. Now try multiplying that number by 2.

Press the × key
Enter 2
Press the = key

The calculator shows *4.912 83* in the window.

What are the limits on the exponent (83 in this case)? Let's experiment to find out.

Multiply 4.912×10^{83} by 1.0×10^{16} to see what happens. With *4.912 83* in the window,

Press the × key
Enter 1
Press the EE key
Enter 16
Press the = key

The calculator displays *4.912 99* in the window. Many calculators use only the two spaces at the far right of the window for the exponent. This means that 99 is the largest exponent that can be displayed.

To see what happens when the exponent is larger than 99, try multiplying this number 4.912×10^{99} by 1×10^{1} with these additional steps:

Press the × key
Enter 1
Press the EE key
Enter 1
Press the = key

What happens? The display window shows an E (that stands for Error Signal). You asked the calculator to work a problem that was too big for it to handle.

To clear this error condition,

Press the *All Clear* key

If the exponent of ten is **more than 99 or less than -99**, most calculators cannot handle the number in scientific notation.

Of course, the first part of a number in scientific notation (if it is a positive one) must be **equal to or less than 9.9999** if there are 5 places saved in the display window for this part of a number.

Most calculators can also handle a **negative number** written in scientific notation. The negative number between one and ten must not be **smaller than -9.9999** if there are 5 places saved in the display window for this part of a number.

EXERCISE: A synthetic thyroid preparation that is available in 25-microgram tablets is prescribed to a patient. The bottle of medication contains 30 tablets.

a. Express the amount of medication in each tablet in grams, in scientific notation.

b. How many grams of medication are in each bottle of medication? (Express in scientific notation).

EXERCISE: A group of researchers conducted independent studies of a bacterium. The researchers reported the average length of the bacteria to be:

A	0.001633 micrometers
B	1.542 nanometers
C	0.001491 micrometers
D	1584 picometers

a. Express each of the above measurements in scientific notation with units of meters.

b. Determine the average of the four researchers' results. (Express your answer in scientific notation.)

c. How far apart are the largest and smallest reported result? (This is called the "range" of the reported results.)

EXERCISE: A 10 gram soil is analyzed to determine how many bacteria it contains. The sample is mixed with distilled water to form 100 ml of solution. A sample of this solution is diluted to 1/10 strength, and 0.1 ml is cultured. From this dilution, a sample is again diluted to 1/10 strength (now 1/10 X 1/10 of full strength) and cultured. This process is continued until a culture is obtained that produces individual colonies (that is, starting with individual bacterium). The culture from the ninth dilution produces 23 colonies.

a. What is the strength of the ninth dilution, as a decimal fraction (expressed in scientific notation) of the strength of the initial soil solution?

b. If 23 bacteria were present in 0.1 mil of the ninth dilution, how many bacteria were present in the 100 ml of the ninth dilution?

c. Divide the number of bacteria in the ninth dilution (determined in Part b) by the strength of the ninth dilution (determined in Part a) to arrive at an estimate of the number of bacteria present in the initial soil sample. (Express this number in scientific notation.)

APPLIED
MATH

WEEK
FOUR

SUPPLEMENTARY WORKSHEET 1: COORDINATE SYSTEMS
Absolute Method

Graphs are often used to help us visualize information. This unit will help you learn some graphing basics, to be used in Computer Numerical Control (CNC) and other classes.

The rectangular coordinate system is formed by drawing 2 lines -- a vertical line and a horizontal line -- which intersect (Figure A).

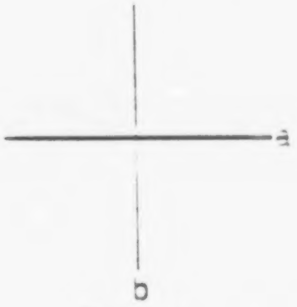


Figure A

It may help you to think of these lines as roads - a road which runs east and west (a), and one which runs north and south (b).

The east-west or horizontal line is (usually) called the x-axis. The north-south or vertical line is (usually) called the y-axis. [These names are the most common way to label the axes (axes is the plural of axis), but the labels may change depending upon the equipment you are using at the time. The procedures are the same in all cases. All of the work on this worksheet will use the x and y labels as stated above.] The point of intersection is called the origin (Figure B).

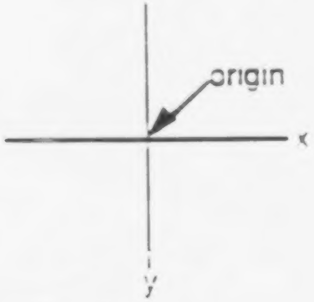


Figure B

To locate points on the graph, we count out from the origin the specified distance, in both the x (across) and y (up and down) directions. To use the road example again, let's say you want to give someone directions to house (a) shown in Figure C. This person is starting from his house, located at the intersection of the two main streets (the origin). (The smaller lines are other streets.) You would tell the person to travel 5 blocks east, then 2 blocks north.

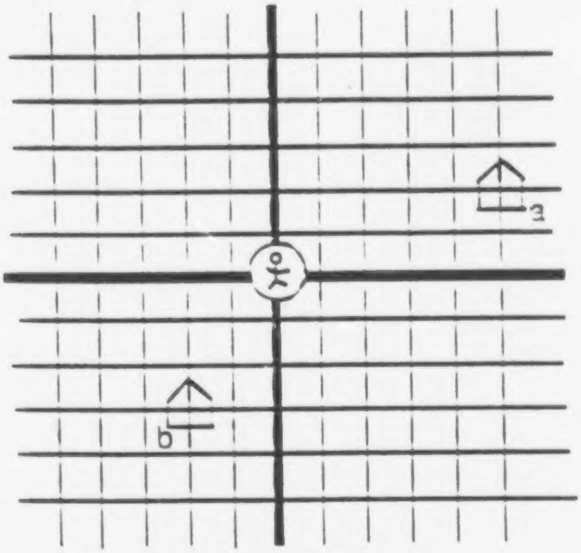


Figure C

To get to house (b) from the main intersection, you would tell the person to travel 2 blocks west, then 3 blocks south.

East corresponds to the positive x-direction. West is the negative x-direction. North is the positive y-direction and south is the negative y-direction (Figure D). So, from the origin, house A is at the point that is in the positive x-direction, at a distance of 5 units, and in the positive y-direction at a distance of 2 units. These units will vary depending, again, upon the machine you are using, but may be inches, millimeters, or just arbitrary units.

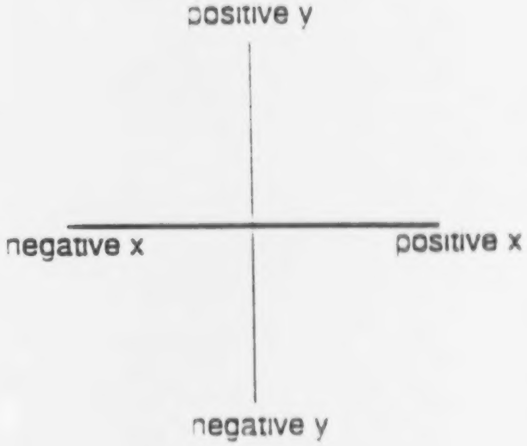


Figure D

It can get awkward to write 3 in the positive x-direction and 2 in the positive y-direction every time you want to state a position on a graph. For the graph with the x and y labels, a short hand method has been developed to solve this problem. Instead of saying all of the above words, an **ordered pair** is used: (3, 2) .

The first number is the x position, or x-coordinate. The second number is the y position or the y-coordinate. The positive or negative sign in front of the number tells whether to move in the positive or negative direction. Remember, if there is no sign written in front of a number, it is positive.

Since the positions are called coordinates, the graph is called a coordinate graph or coordinate plane. The placement of a point on the graph is called graphing or plotting a point. Thus, house (a) back in Figure C is at point (5, 2) and house (b) is at point (-2, -3) . The coordinates of the origin are (0, 0) .

So, to plot point W (2, -3), starting at the origin, you count out 2 to the positive x-direction (to the right) and count 3 in the negative y-direction (down) (Figure E). Also on Figure E are point x at position (-2, 4) and point y at position (1, 2).

Try plotting these points on Figure E. Then, check your plotting with the answers provided at the end of this worksheet.

M (-4, 3)
N (3, 2)
P (0, -4)
R (-3, -1)

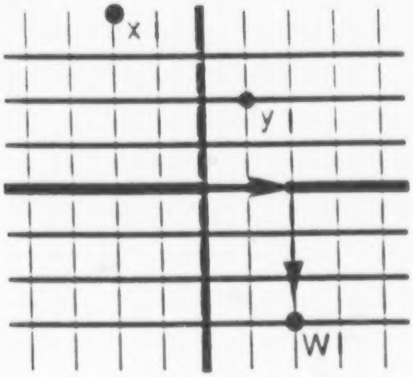


Figure E

This type of graphing is called **absolute** because you are always starting at the origin.

Assignment

1. Plot and label the following points using the absolute system of plotting.

A (-4, 13)
B (5, -6)
C (-9, -6)
D (-11, -2)
E (5, 12)
F (-9, 12)
G (-2, 8)
H (-12, 2)
I (0, 13)

J (10, 10)
K (-14, 10)
L (8, 2)
M (-2, 3)
N (1, -5)
O (-5, -5)
P (7, -2)
Q (-2, -7)
R (-2, 11)

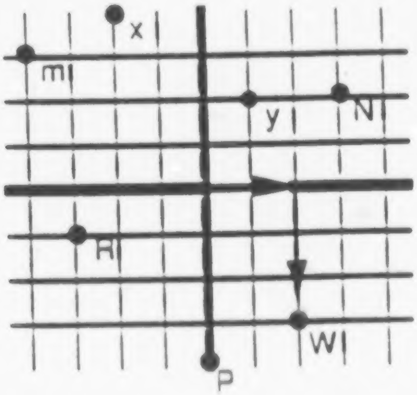
2. Connect the points as shown below. A picture should result.

RQ
GE
MN
IR
DM
KH
BN

FG
CO
EJ
AR
FK
CD

PM
OM
LM
HM
LJ
BP

Answers to absolute graphing practice



5 Divisions/inch

Rectangular Coordinate System

Using a coordinate system, draw to scale a floor plan of your classroom. Label several important positions in the floor plan (doors, windows, tables, etc.) With their coordinates. Use the floor plan to determine some distances that you have not measured, then check your findings. What scale did you choose for your floor plan and why?

6

SUPPLEMENTARY WORKSHEET 2: COORDINATE SYSTEMS

Incremental Method

Many machines use a different plotting system - not the absolute system. This other system is called the incremental system. In the incremental system, the graph looks the same, with the x and y axes, etc., but the points are positioned differently.

The only point that is plotted from the origin is the first one. After that, each point is measured from the preceding point.

For example, given the points A (4, 5), and B (-3, -2). Point A would be plotted as before: you would start counting from the origin, and count 4 in the positive x-direction and 5 in the positive y direction (Figure F) .

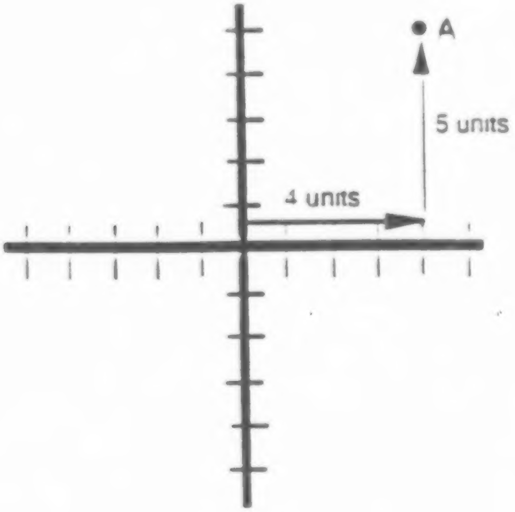


Figure F

Then, **starting from point A** (not the origin), you would plot point B by going 3 in the negative x-direction and 2 in the negative y direction. Another way to say that is that you'll count back 3 and down 2, from point A (Figure G) .

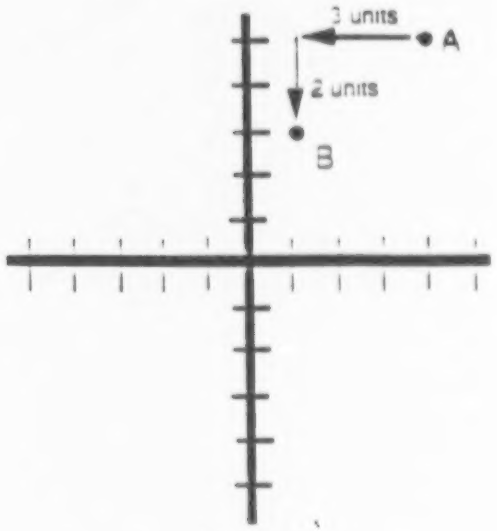


Figure G

To plot the next point, you would start counting from point B. For example, if point C is (-5, 2), it would be placed as shown in Figure H.

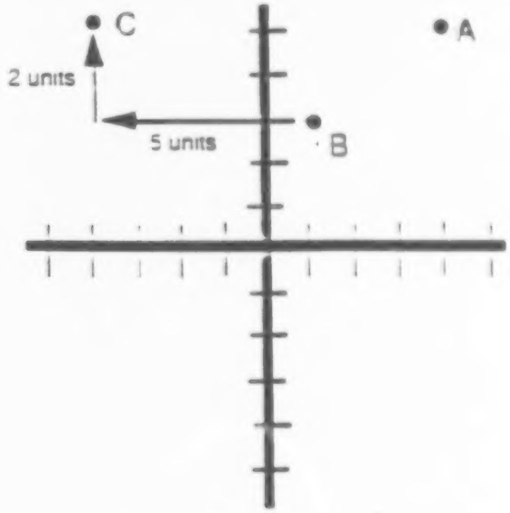


Figure H

Incremental plotting is often used in CNC machinery and involves both the x and y coordinates as well as a z coordinate. The three dimensional graphing will not be covered here, but is used extensively in machining.

Assignment

1. Plot (and label) the following points, in the order they are given. Remember, this is the incremental method of graphing points!

A (3, -14)
B (0, 17)
C (4, 2)
D (0, 5)
E (-2, -2)
F (-2, 2)
G (-2, -2)
H (-2, 2)
I (0, -5)
J (4, -2)
K (0, -10)
L (-7, 8)
M (2, -7)
N (5, -1)
O (5, 1)
P (2, 7)
Q (-7, -8)

2. Connect the points in order (i.e. AB, BC, CD, etc.). A picture should result.

5 Divisions/inch

5 Divisions/inch

Incremental Method

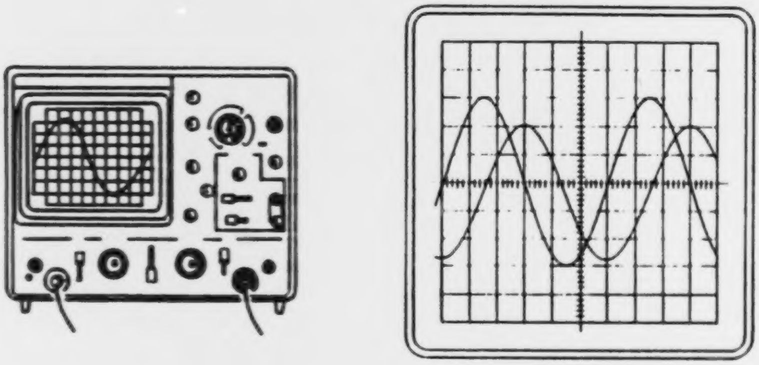
Draw a picture on graph paper. Write the directions for drawing the picture using the incremental method. Give your directions to another student. Have them follow the directions and see if they arrive at the picture you started with.

LEARNING THE SKILLS

INTRODUCTION

When you listen to music do you ever think about what sound waves *look* like? Or when you use electricity to run an appliance, do you think about what an electrical current *looks* like? The *oscilloscope* is an instrument that can change sounds and currents into a picture. Such pictures are shown on the face of a tube similar to a television picture tube.

When pure musical tones are changed into pictures you can see on an oscilloscope, these tones have a regular wave-like pattern. Alternating electrical currents pictured on an oscilloscope also have a wave pattern. Figure 1 shows typical wave patterns displayed by an oscilloscope.



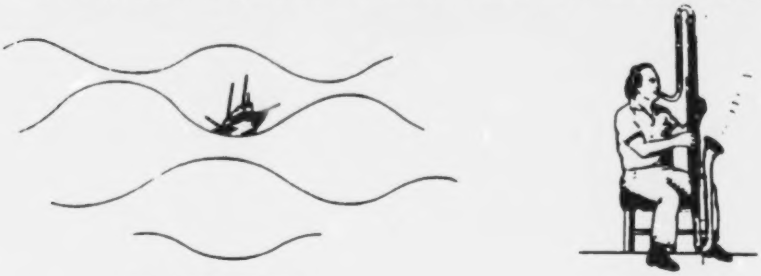
a. Voltage signal on oscilloscope

b. Wave patterns for pure tones

Figure 22-1
Typical wave patterns

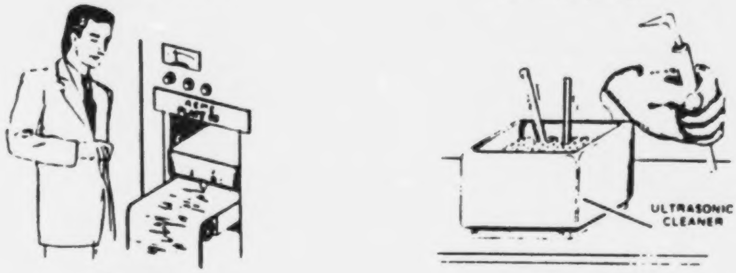
Waves are a way of describing regular motions. Waves can be either helpful or harmful. For example, vibration waves in equipment can cause damage to engines, destroy solder joints, and cause open circuits in electronic equipment. On the other hand, ultrasonic waves are used to clean instruments and "see" inside the human body.

There are many kinds of waves. You have probably seen ocean waves or the waves created by a boat moving through water. The motion of earthquakes occurs in waves, recorded on an instrument called a *seismograph*. Figure 22-2 shows examples of different types of waves.



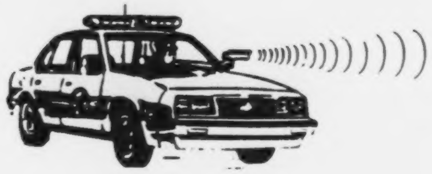
a. Water waves

b. Sound waves



c. Ground waves caused by an earthquake

d. Sound waves help clean.



e. Microwaves

Figure 22-2
Different types of waves

Trigonometry, which makes use of the triangle ratios explained in Unit 21, helps us describe waves and vibrations. Knowing about the characteristics of waves makes it easier to produce and control sounds, vibrations and electrical current.

As you watch the video for this unit, notice how people on the job picture sound, vibrations, and current as waves.

PRACTICING THE SKILLS

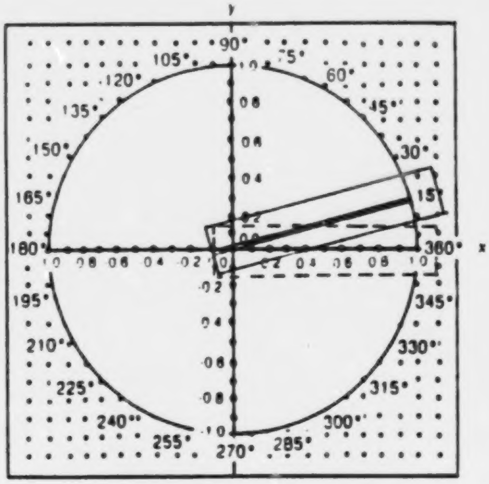
Laboratory Activities

Use the mathematics skills you have learned to complete one or all of the following activities:

Activity 1: Unit circle

Equipment Calculator

Unit circle board consisting of a 2 ft × 2 ft piece of pegboard with x- and y-axes marked. (See drawing below.)

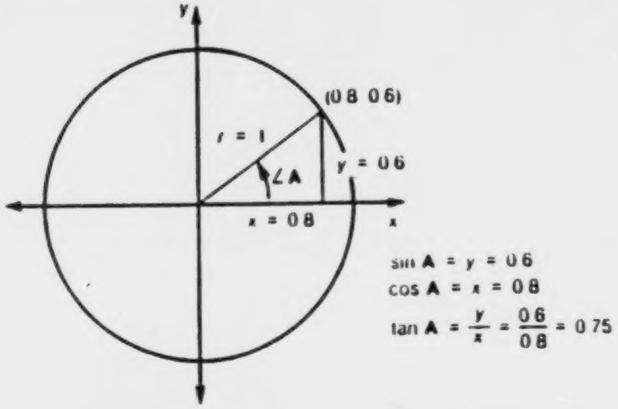

y
90°
105°
75°
120°
60°
135°
45°
150°
30°
165°
15°
180°
360°
x
195°
345°
210°
330°
225°
315°
240°
300°
255°
270°
285°
1.0
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1.0

Unit circle on pegboard

Note: The scale on the two axes extends from −1 to +1. Each scale division of 0.1 value stands for *one inch*. Thus the end points of +1 and −1 represent lengths of +10 inches and −10 inches. A circle of 10-inch radius is centered at the origin that's marked on the board. The circle is labeled at 15° increments. The four quadrants of the coordinate system are identified. A clear plastic rectangle is attached at the origin so it can rotate freely. The rectangle has a line printed on it to represent the radius of the circle. The line begins at the origin and extends out to a length of 10 inches.

Statement of Problem

In this activity, you examine the meaning of the *trigonometric functions* with the help of a unit circle. The *unit circle* has a radius of *one unit.* When the unit circle is on a Cartesian coordinate system—with its center at the origin—a radius drawn from the origin to a point (x,y) on the circle forms the hypotenuse of a right triangle. This triangle has legs of length x and y, and a hypotenuse of length 1. See the drawing below.



Trigonometric functions of angle A on a unit circle

The sine of an angle is defined as the ratio, $^{\text{side opp}}/_{\text{hyp}}$. Thus, in the drawing above, the sine of angle A is equal to the ratio $^{y}/_{1}$, or simply y. The *sine of angle* A is, therefore, equal to the y-value of the point on the unit circle. In the same way, the *cosine of angle* A, defined as the ratio of $^{\text{side adj}}/_{\text{hyp}}$ is equal to the ratio $^{x}/_{1}$, or simply x. Taking this one step farther, the tangent of angle A—defined as the ratio $^{\text{side opp}}/_{\text{side adj}}$—becomes $^{y}/_{x}$.

Procedure

a. Position the radius (line on plastic rectangle) of the "unit circle board" on the 15° mark. Read the y- and x-values for the point on the unit circle at the end of the radius. (For example, in the drawing shown above, for angle A, $y = 0.6$ and $x = 0.8$.) Write the values you read on a sheet of paper.

b. Repeat Step a for 30°, 45°, 60°, 75°, 90° (positive y-axis), 105°, 120°, 135°, 150°, 165°, 180° (negative x-axis), 195°, 210°, 225°, 240°, 255°, 270° (negative y-axis), 285°, 300°, 315°, 330°, 345°, 360° (positive x axis)

c. Use the "unit circle board" and your data from Steps a and b to answer the following questions.

1. What is the *sign* of the y-value in quadrant I? In quadrant II? In quadrant III? In quadrant IV?

2. What is the *sign of the sine of an angle* in quadrant I? In quadrant II? In quadrant III? In quadrant IV?

3. What is the *sign* of the x-value in quadrant I? In quadrant II? In quadrant III? In quadrant IV?

4. What is the *sign of the cosine of an angle* in quadrant I? In quadrant II? In quadrant III? In quadrant IV?

5. What is the *sign* of the y-value divided by the x-value in quadrant I? In quadrant II? In quadrant III? In quadrant IV?

6. What is the *sign of the tangent of an angle* in quadrant I? In quadrant II? In quadrant III? In quadrant IV?

Calculations

a. Divide the y-value by the x-value for each of the angles recorded in Steps a and b. Write the result on your data paper as the "calculated tangent" of the angle.

b. Use the appropriate key on your scientific calculator and calculate the sine, cosine, and tangent for each of the angles recorded in Steps a and b.

c. Compare the x, y, and "calculated tangent" values to the values you get for cosine, sine, and tangent using your scientific calculator.

d. Choose several arbitrary angles and use the calculator to calculate the sine and cosine of each of these angles. Divide the sine of each angle by the cosine of the same angle. Calculate the tangent of each angle. Compare the value of the tangent of an angle to the value of the sine of that angle divided by the cosine of that angle. Can you conclude that $\tan A = {}^{\sin A}/_{\cos A}$?

Challenge

An identity that is commonly used in trigonometry is $\sin^2 A + \cos^2 A = 1$. Use your data from the unit circle and the Pythagorean formula to show that this identity is true.

GRAPHING THE SINE FUNCTION

You may already know one definition for the *sine ratio* (or sine function) for one of the acute angles in a right triangle. For example, Unit 21 defined the sine of ∠A as the ratio of the side opposite ∠A (side *a*) to the hypotenuse of the right triangle (side *c*). Figure 22-3 shows this.

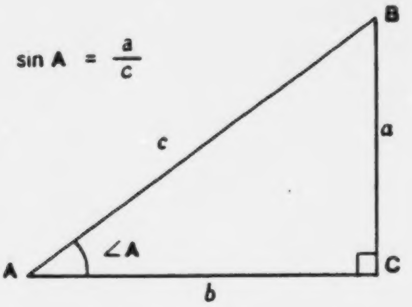
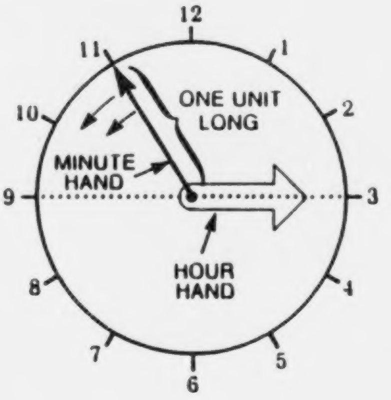


Figure 22-3
The sine ratio

Defining the sine another way

The face of a clock can help you see *another* way to understand the *sine of an angle*. Imagine that you have a very *unusual clock*—as shown to the right. It has a minute hand *one unit long* that moves backward and an hour hand that always points to 3 on the clock face! The minute hand extends out to the edge of the circle on the clock face. The horizontal dotted line that divides the clock in half along the hour hand (from 3 to 9) is painted on the face of the clock.



The left drawing in Figure 22-4 shows the clock face with both hands pointing to 3. (Another way to say this is that both hands lie along the positive x-axis). Move the minute hand (remember, it goes backward) until it points to "2" on the clock face. See the drawing at the right in Figure 22-4. The angle between the two hands is $\angle A$.

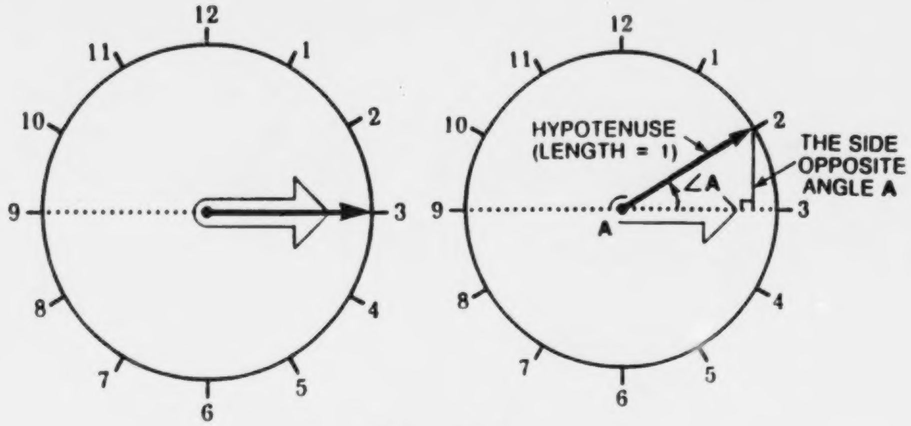


Figure 22-4
Another way to understand the meaning of the sine of an angle

Now draw a line from the end of the minute hand straight down to form a right angle with the horizontal dotted line. Notice that $\angle A$, between the two hands, is inside the triangle formed by the two hands and the vertical line.

In the triangle shown, the perpendicular line from the end of the minute hand to the horizontal line, (x-axis) is the *side opposite* $\angle A$. The *minute hand* is the *hypotenuse* of this triangle. It is *one unit* of length (one inch, one centimeter, etc.) and extends out to the edge of the circle.

The sine of angle A is equal to the ratio of *opp* over *hyp*, or a/c. Since the hypotenuse (or c) always has a value of *one* (because this clock has a minute hand that is one unit long), this ratio is $a/1$ or just a. Don't forget that the *length* of the side opposite $\angle A$ is always measured *in the same units of length* as the minute hand.

The sine of $\angle A$ (formed by the two hands of this unusual clock) is simply equal to the length of the vertical line (the side opposite $\angle A$).

Defining the sine for angles over 90°

Figure 22-5 shows (for several different angles) the *vertical line* whose length is equal to the sine of ∠A. With this simple definition of the sine (the length of the vertical line) you can use the clock face to measure the sine of any angle, from 0° to 360°, rather easily. Each angle is formed as the minute hand moves continuously around the clock face, until it meets the hour hand again at 3 (or the positive x-axis).

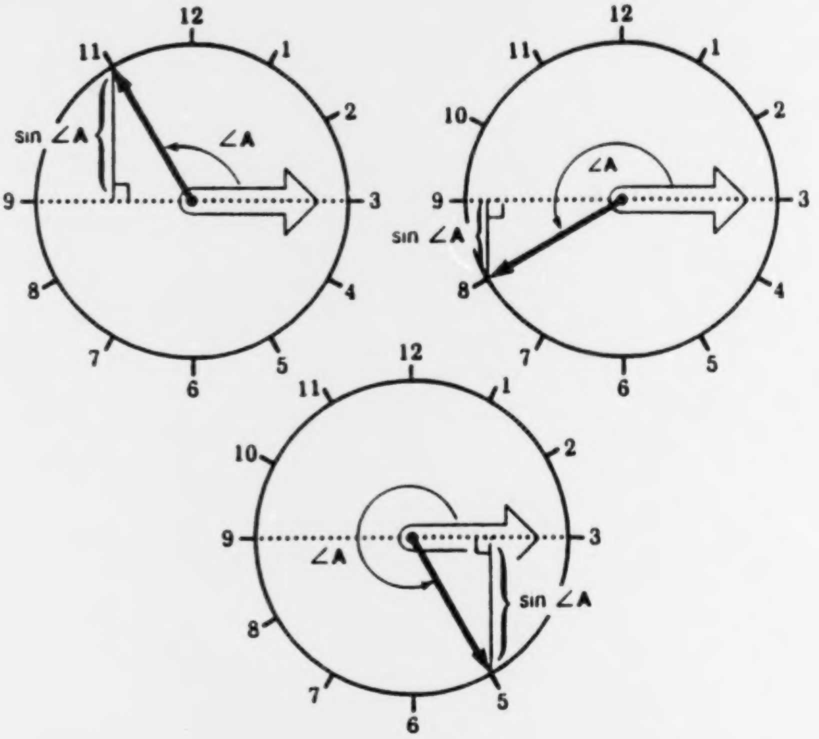


Figure 22-5
The sine as the length of a vertical line

The first clock (on the left) in Figure 22-5 shows an ∠A that is between 90° and 180°. As the minute hand continues to move backward, the second clock (on the right) shows an ∠A that is between 180° and 270°. The third clock shows an angle that is between 270° and 360°. Notice carefully that in each instance, ∠A is drawn from the *stationary hour hand to the moving minute hand.* It is not necessary that ∠A be inside the triangle that contains the right angle. Nevertheless, in each of these drawings, *the length of the vertical line is equal to the sine of* ∠A.

This *unusual clock* provides you with a way to measure the sine of all angles—even those that are larger than 90°. For example, when the minute hand points to 11 on the clock face, the hands form an angle of 120°.

The first clock in Figure 22-6 shows the sine of 120°. If the minute hand is drawn exactly *one inch long*, then you might use a ruler to obtain the value of sin A simply by measuring *the length of the vertical line*—in inches.

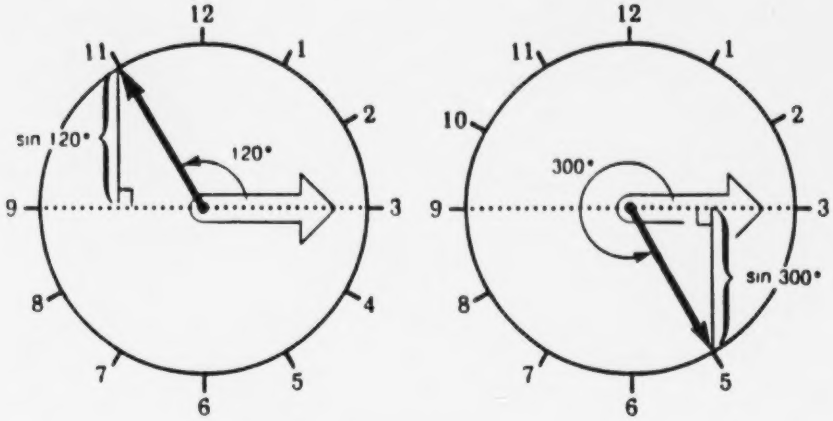


Figure 22-6
Finding the sine of an angle

Calculating values for the sine of an angle

Instead of trying to measure the vertical line to find the value of sin 120°, it is much easier to use your calculator!

To find sin 120° with your calculator:

Make sure your calculator is in the *degree mode*. Many calculators are in the *degree mode* when you turn them on. The window may show *DEG* to tell you that it is in the *degree mode*.

Enter 120 (the angle in degrees).
Press the *sin* key.
Read the number in the window for the value of sin 120°.

The calculator gives you the correct value for sin 120° and also puts the correct sign (+ or –) on the value. Thus,

$$\sin 120° = 0.866 \text{ (positive value)}$$

Look at the second picture in Figure 22-6. Notice that the vertical line segment for this angle (300°) is the same length as the vertical line segment for sin 120°. But this time the vertical line segment *goes down* from the *x*-axis, so the line segment has a *negative value*. That means that sin 300° should have the same numerical value as sin 120°, but with a negative sign. What does your calculator give you for sin 300°? Does it give you sin 300° = –0.866?

When an angle is shown on the *unusual clock* we're using, if the minute hand for the clock is in the **first or second quadrant**, then the vertical line segment extends **up** from the *x*-axis, and the sine of the angle is **positive**. If the minute hand for the angle is in the **third or fourth quadrant**, the vertical line segment extends **down** from the *x*-axis, and the sine of the angle is **negative**.

Study Activity: Copy the chart given below and *use your calculator* to fill in the values for sin A. Round values to the nearest hundredth place.

∠A	sin A	∠A	sin A
0°		180°	
30°		210°	
45°		225°	
60°		240°	
90°		270°	
120°	0.87	300°	–0.87
135°		315°	
150°		330°	
		360° (same as 0°)	

When you have completed your chart, you can use these values to graph the sine function. That is, you can make a graph of $y = \sin A$ for values of ∠A from 0° to 360°.

Graphing the sine curve

Study Activity:

To graph the sine curve, draw a coordinate system on a sheet of paper, similar to the one shown below in Figure 22-7. The next paragraph has some hints about what size units to use.

Along the positive x-axis, you are going to graph (or plot) the values of the angle, from 0° to 360°. Make the distance from 0° to 120° approximately the same length as the distance from 0 to 1 on the y-axis. Along the y-axis, you are going to plot (or graph) the values of the sine function, or sin A.

We are using a rectangular coordinate grid with x and y axes. So let's substitute x for $\angle A$, and let the curve $y = \sin A$ become $y = \sin x$.

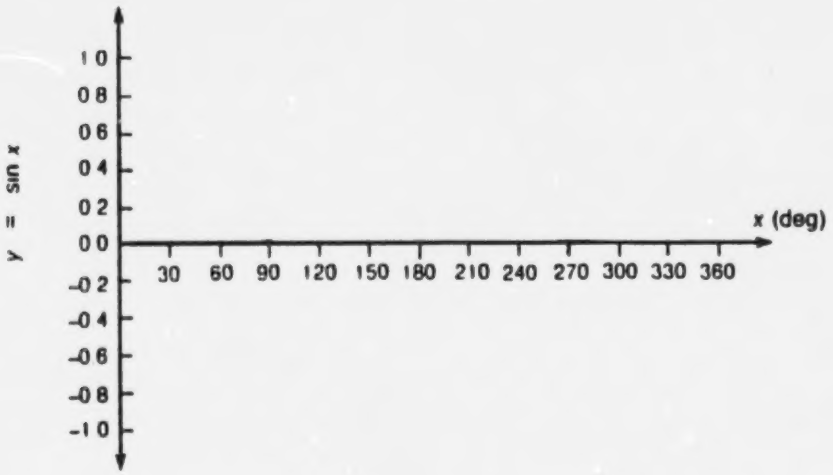


Figure 22-7
Coordinate system for a sine graph

Plot all the points using the paired values from the completed chart that follows. The x-value stands for the *angle* and the y-value stands for the *sine of that angle*. Each point on the graph represents the paired x- and y-values, or x and $\sin x$. Notice that you will have to estimate the position along the y-axis of such values as $\sin x = 0.71$ and $\sin x = 0.87$.

Science Curriculum

WEEK 1: FOOD SCIENCE

1. Introduction (10-15 min.)
   I.F.T. video and brochures (20 min.)
   -"What is food science?"
   Sensory Evaluation

2. "The Effect of Heat - pH on Green Vegetables"
   from "Experiments in Food Science"
   - pH definition; litmus paper
   - cell structure - plants
   - Abbreviations (HCl, NaOH, etc.)
   - percent solutions
   - cause and effect discussions
   - measurements

3. "Subsurface Mold Growth in Foods"
   - microscope work
   - molds - types of growth
   - data collection and discussion
   from "Experiments in Food Science"

4. "Enzymatic Browning"
   from "Experiments in Food Science"
   - definition of catalyst, enzymes
   - data collection
   - percents, dilution series

EXPERIMENT 1

THE EFFECT OF HEAT AND pH ON THE COLOR AND TEXTURE OF GREEN VEGETABLES

BACKGROUND

Cell Wall Structure:

The cell is the basic structural unit of all plant tissues. These cells are surrounded by cell walls that provide an elastic support for retaining the contents of the cell. The cell also has a cell membrane layer, which is located just inside the cell wall and which controls the passage of liquids into and out of the cell. The cell is filled with a jell-like substance, termed the cytoplasm, which is composed of protein, sugars, salts, and other substances dispersed in water. Mature cells also contain vacuoles, which are separate compartments filled with a fluid, cell-sap, and which are composed of dissolved sugars, salts, organic acids, pigments and other materials. Also located within the cytoplasm are separate inclusion bodies, called plastids, which contain the pigment chlorophyll. These plastids are only about 4 to 10 nm in diameter.

Pigments:

Green vegetables contain the green pigment chlorophyll, which plays a key role in transferring light energy to chemical energy during the growth and development of the plant by the process of photosynthesis. Examples of such green vegetables include spinach, peas, beans, cabbage, lettuce and celery.

Vegetables Processing:

It is necessary to process green vegetables to preserve them for a year-round food source. The most common commercial method of preservation is canning. For this process, the vegetables are cleaned, trimmed, cut, packed into cans, sealed and heated to sufficiently high temperatures (in the order of $240^{o}F$) to destroy spoilage and disease causing microorganisms. Such heat treatments also produce a number of undesirable chemical and textural changes in the vegetables. The textural changes are due to partial destruction of the cell wall and cell membrane. Heat treatments also cause chemical alteration of the green pigment chlorophyll, thus resulting in a processed vegetable with less green color. It is important for the food processor to control pH of the water added to the vegetables prior to canning. Most processes require that the pH be near neutral (about 6 to 7) to minimize the above adverse chemical reactions that cause loss of texture and color acceptability of the canned green vegetable.

pH Definition:

There are a number of definitions of pH, but for our purposes the degree of acidity or alkalinity of a solution is usually measured in terms of the pH scale. A neutral solution (contains equal concentrations of acid and alkali) has a pH of 7. Acidic solutions have pH values below 7 and alkaline solutions have pH values above 7. The lower the pH value, the stronger the acid concentration and the higher the pH value above 7, the stronger the alkali concentration in the solution.

EXPERIMENTAL

In this experiment you will investigate the effect of heat and pH upon the color and texture of green beans. The pH of the solutions will be adjusted to alkaline and acidic conditions, but the heating time and all other conditions will be held constant.

Materials:

1. Fresh or frozen green beans
2. Dilute HCl solution (.01N HCl)
3. Dilute NaOH solution (.01N NaOH)
4. Distilled water or tap water

Equipment and Supplies:

1. Bunson burner
2. Timer or wall clock
3. 250 ml beakers with watch glasses
4. 100 ml graduated cylinders
5. Weighing balance
6. 12-15 cm filter paper discs
7. Stirring rods or magnetic stirrer
8. Heat resistant gloves or tongs
9. Spatula or table fork
10. Litmus paper strips or pH indicating paper
11. Marking pen

Procedure:

1. Label four beakers, cylinders and filter paper discs:

   1) 0.01N HCl

5. What pigment is responsible for the observed changes in color of the cooked vegetables?

6. What reactions are responsible for loss of texture in cooked green beans?

VOCABULARY OF TECHNICAL TERMS

1. Pigment
2. Chlorophyll
3. Acid
4. Alkali
5. Acidic
6. Alkalinity
7. pH
8. Litmus paper or pH indicator paper
9. nm (nanometer)
10. Color
11. Texture

TREATMENT	pH	COLOR				TEXTURE (SCALE 1 to 10)
		DRAINED SOLUTION		DRAINED BEANS		
		CHARACTERISTIC	INTENSITY SCALE (0 to 10)	CHARACTERISTIC	INTENSITY SCALE (0 to 10)	
UNHEATED CONTROL						
HEATED CONTROL						
ACETIC ACID						
SODIUM BICARBONATE						

EXPERIMENT 2

SUBSURFACE MOLD GROWTH IN FOODS

INTRODUCTION

Molds are found nearly everywhere in our environment. When present on fresh or processed foods, molds may grow and cause an unsightly appearance and off-flavors. In addition, some molds are capable of producing mycotoxins which are hazardous to human health.

Foods and beverages are processed in such a way as to inhibit the growth of molds naturally present on the raw product. If processed foods are stored in dishes or other containers which are contaminated with molds, these foods may spoil. Molds are variously colored. Many are white and cottony in appearance while others are green, brown, black, pink or grey.

Although some molds will grow on a wide variety of foods, others tend to grow only on fresh fruits or vegetables, while still others grow best on bread or cheese. Each mold consists of (1) "aerial" growth which we can see by examining the external surface of the spoiled food and (2) "submerged" growth which may actually penetrate the food surface to a depth of 2 cm or more. Submerged growth can generally be observed only by first removing the aerial growth and then examining the food using a microscope.

PURPOSE

In this experiment you will examine molds on two types of spoiled foods.

MATERIALS

Moldy foods, stereo microscope (if available, otherwise a standard stage microscope), glass slides for microscope, knife (or scalpel).

PROCEDURE

A. Preparation:

1. Set out a half slice of bread (without preservatives such as sodium benzoate, potassium sorbate or sodium propionate), if possible) in a closed container (have a 3-5 cm open space above sample) on your lab table or a window sill. Leave it for a few days until it gets moldy. Keep the bread moist by adding a few drops of water each day.
2. Slice a piece of apple and set it out also in a closed container in the same manner as the bread.

3. Slice a piece of natural cheese and set it out also in a separate closed container following the same procedure.

B. Observing the uncontaminated food:

1. Using a knife or scalpel, remove a small amount of the apple by scraping and place on a glass slide.
2. Observe using the stereo microscope, or the standard stage microscope at 100X and 500X magnification.
3. Break off some tiny pieces of bread and observe under the microscope. Repeat for cheese.

C. Observing aerial mold structures:

1. Using a knife, remove a small piece of mold from the surface of the bread and place it on the slide. Be careful not to get any of the bread in the sample.
2. Observe under the microscope.
3. Repeat for the apple or cheese or both.

D. Observing submerged mold:

1. Scrape or cut the visible mold from the surface of the bread. Don't cut too deeply into the bread, however.
2. Cut or break off a small sample of the bread about 1 cm deep, directly below the area you just scraped, and observe under the microscope.
3. Repeat for the apple or cheese or both.

DATA

Sketch below picture of (1) the food with no mold growing, (2) the aerial mold growth and (3) the submerged mold growth with food particles that you observed in the microscope.

	(1) Plain Food	(2) Aerial Mold	(3) Submerged Mold and Food
Bread			
Apple			
Cheese			

CONCLUSIONS

What can you conclude about the sanitary condition of foods from which only the aerial mold growth has been removed?

QUESTIONS

1. Is a moldy food okay to eat if you just brush away aerial mold growth? Why or why not?
2. Why do fresh fruits and vegetables get soft when mold grows on them?
3. Are all molds growing in or on foods undesirable? Why or why not?
4. How can you prevent or delay molds from growing on foods?

EXPERIMENT 6

ENZYMATIC BROWNING

INTRODUCTION

Substances which speed-up reactions between other chemicals but which themselves are neither destroyed nor chemically changed during the reaction are called catalysts.

A recent application of catalysts that you have probably heard about is the catalytic converter in automobile exhaust systems. The converter changes potentially harmful exhaust gases into harmless CO_2 and various oxides of nitrogen. The catalyst speeds up the reaction in the converter to greatly minimize the quantity of noxious gases that escape into the atmosphere.

Catalysts can be destroyed or inactivated by a variety of means. This is why all cars equipped with catalytic converters are required to use unleaded gasoline. The tetraethyl lead in the leaded gasolines destroys the catalyst.

One group of catalysts, found in biochemical reactions, is called enzymes. They can be desirable or detrimental to the food processor depending on the particular enzymes and the specific food systems.

Examples of useful enzymes in the food industry are: rennin, used to coagulate milk during cheesemaking; protease, used to tenderize meat; and isomerase, used to make liquid sugar. There are many more. Can you think of any?

Examples of undesirable enzymes in the food industry include: lipase, which causes rancidity in butter and other cooking oils; and peroxidase which can lead to the destruction of vitamin C in plant tissue.

PURPOSE

The particular enzyme you will be studying in this experiment is polyphenol oxidase. It is the enzyme that is naturally present in many fruits and vegetables which causes them to turn brown when they are cut and exposed to air. Specifically, the object of this experiment is to investigate methods used by food processors to inactivate this enzyme.

MATERIALS

Food materials, organic acids, beakers, tongs, paper towels.

PROCEDURE

1. Your instructor will either provide you with fresh food materials or tell you what to bring to class.

2. Label 5 beakers so you can distinguish among the following solutions:

    a. Ascorbic Acid 0.1%
    b. Citric Acid 0.1%
    c. Acetic Acid 0.1%
    d. Acetic Acid 1.0%
    e. Water

3. Fill each beaker with enough solution so that the piece of food can be completely covered.

4. After the solutions are prepared, cut the food into six approximately equal pieces. Using the tongs, dip one of four separate pieces into each of the first four solutions and set them in order on a paper towel. Rinse the tongs in clear water after each dipping. Drop the fifth piece in the water and leave it there. Set the sixth, untreated piece off to one side on a paper towel. Try to prepare all six samples as quickly as possible and note the time when you finished.

5. Check all 6 samples after 5, 10, and 20 minutes. Note the extent of browning on the surface of each piece of food.

DATA

Prepare a table in your notebook similar to the one below to record the color changes observed in step 5.

	COLOR AT		
	5 min.	10 min.	20 min.
Sample 1			
Sample 2			
Sample 3			
Sample 4			
Sample 5			
Sample 6			

CONCLUSIONS

What can you conclude about the effectiveness of the solutions used to prevent enzymatic browning? Which treatment, if any, appeared to be the most effective? Which the least?

QUESTIONS

1. What was the specific purpose of the ascorbic acid? citric acid? acetic acid?
2. Why didn't the piece of food in the water turn brown as fast as the one in the air?
3. Name some food processes in which enzymatic browning is undesirable.

FOOD SCIENCE

Sensory Evaluation: Triangle Test

Objective: To determine which is the different sample.

Procedure:

1. You will receive a set of three samples. Two of the three will be the same, one will be different. Your goal is to pick the different one.
2. Before trying a sample, you will need to cleanse your palate -- to allow you to get a true taste of the sample.
    a. Take a bite of the cracker provided, chew, and swallow.

    b. Rinse your mouth with water.

    This must be done before each sample.
3. Take a small bite of the sample. You may want to save a bit for an additional tasting.
4. Cleanse your palate and try the next sample.

This test is done in the food industry to determine whether a change to a product has resulted in an improved product. If the change cannot be detected, the manufacturer may not implement the change. The test can also give the manufacturer input about whether the change is favorable or not.

QUESTIONS

1. Which was the different sample?

△ ○ □

2. Describe how you could tell it was the different sample. (This will be used in a descriptive writing project in Applied English class).

Week 1: Food Science

Monday: Introduction: What is Food Science?
Video: "In Good Taste--Careers in Food Science"
Triangle Taste Test

Tuesday: Lab: "The Effect of Heat and pH on Green Vegetables"

Wednesday: Lab: "Subsurface Mold Growth in Foods"

Thursday: Lab: "Enzymatic Browning"

Laboratory: "Subsurface Mold Growth in Foods"

From: "Experiments in Food Science", Institute of Food Technologists

INTRODUCTION

Molds are found nearly everywhere in our environment. When present on fresh or processed foods, molds may grow and cause an unsightly appearance and off-flavors. In addition, some molds are capable of producing mycotoxins which are hazardous to human health.

Foods and beverages are processed in such a way as to inhibit the growth of molds naturally present on the raw product. If processed foods are stored in dishes or other containers which are contaminated with molds, these foods may spoil. Molds are variously colored. Many are white and cottony in appearance while others are green, brown, black, pink or grey.

Although some molds will grow on a side variety of foods, other tend to grow only on fresh fruits or vegetables, while still others grow best on bread or cheese. Each mold consists of (1) "aerial" growth which we can see be examining the external surface of the spoiled food and (2) "submerged" growth which may actually penetrate the food surface to a depth of 2 cm or more. Submerged growth can generally be observed only be first removing the aerial growth and then examining the food using a microscope.

PURPOSE

In this experiment you will examine molds on two types of spoiled foods.

MATERIALS

Moldy foods, microscope, glass slides for microscope, scalpel.

PROCEDURE

A. Preparation:

1. Set out a half slice of bread (without preservatives such as sodium benzoate, potassium sorbate or sodium propionate), in a closed container (have a 3 - 5 cm open space above sample) on a lab table or a window sill. Leave it for a few days until it gets moldy. Keep the bread moist by adding a few drops of water each day.

2. Slice a piece of apple and set it out also in a closed container in the same manner as the bread.

3. Slice a piece of natural cheese and set it out also in a separate closed container following the same procedure.

B. Observing the uncontaminated food:

1. Using a knife or scalpel, remove a small amount of the apple by scraping a place on a glass slide.
2. Observe using the microscope at 100X and 500X magnification.
3. Break off some tiny pieces of bread and observe under the microscope. Repeat for cheese.

C. Observing aerial mold structures:

1. Using a knife, remove a small piece of mold from the surface of the bread and place it on the slide. be careful not to get any of the bread in the sample.
2. Observe under the microscope.
3. Repeat for the apple and cheese.

D. Observing submerged mold:

1. Scrape or cut the visible mold from the surface of the bread. Don't cut too deeply into the bread.
2. Cut or break off a small sample of the bread about 1 cm deep, directly below the area you just scraped, and observe under the microscope.
3. Repeat for the apple and cheese.

DATA

Sketch below a picture of (1) the food with no mold growing, (2) the aerial mold growth and (3) the submerged mold growth with food particles that you observed in the microscope.

	Plain Food	Aerial Mold	Submerged Mold
Bread			
Apple			
Cheese			

CONCLUSIONS

What can you conclude about the sanitary condition of foods from which only the aerial mold growth has been removed?

QUESTIONS

1. Is a moldy food okay to eat if you just brush away the aerial mold growth? Why or why not?
2. Why do fresh fruits and vegetables get soft when mold grows on them?
3. Are all molds growing in or on foods undesirable? Why or why not?
4. how can you prevent or delay molds from growing on foods?

Laboratory: "Subsurface Mold Growth in Foods"

From: "Experiments in Food Science". Institute of Food Technologists

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1. Using a knife, remove a small piece of mold from the surface of the bread and place it on the slide. be careful not to get any of the bread in the sample.

2. Observe under the microscope.

3. Repeat for the apple and cheese.

D. Observing submerged mold:

1. Scrape or cut the visible mold from the surface of the bread. Don't cut too deeply into the bread.

2. Cut or break off a small sample of the bread about 1 cm deep, directly below the area you just scraped, and observe under the microscope.

3. Repeat for the apple and cheese.

DATA

Sketch below a picture of (1) the food with no mold growing, (2) the aerial mold growth and (3) the submerged mold growth with food particles that you observed in the microscope.

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Apple			
Cheese			

CONCLUSIONS

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QUESTIONS

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2. Why do fresh fruits and vegetables get soft when mold grows on them?

3. Are all molds growing in or on foods undesirable? Why or why not?

4. how can you prevent or delay molds from growing on foods?

Laboratory:

"The Effect of Heat and pH on the Color and Texture of Green Vegetables"

From "Experiments in Food Science", The Institute of Food Technologists.

BACKGROUND

Cell Wall Structure:

The cell is the basic structural unit of all plant tissues. These cells are surrounded by cell walls that provide an elastic support for retaining the contents of the cell. The cell also has a cell membrane layer, which is located just inside the cell wall an which controls the passage of liquids into and out of the cell. The cell is filled with a jell-like substance, termed the cytoplasm, which is composed of protein, sugars, salts, and other substances dispersed in water. Mature cells also contain vacuoles, which are separate compartments filled with a fluid, cell-sap, and which are composed of dissolved sugars, salts, organic acids, pigments and other materials. Also located within the cytoplasm are separate inclusion bodies, called plastids, which contain the pigment chlorophyll. These plastids are only about 4 to 10 nm in diameter.

Pigments:

Green vegetables contain the green pigment chlorophyll, which plays a key role in transferring light energy to chemical energy during the growth and development of the plant by the process of photosynthesis. Examples of such green vegetables include spinach, peas, beans, cabbage, lettuce and celery.

Vegetables Processing:

It is necessary to process green vegetables to preserve them for a year-round food source. The most common commercial method of preservation is canning. For this process, the vegetables are cleaned, trimmed, cut, packed into cans, sealed and heated to sufficiently high temperatures (in the order of 240 degrees F) to destroy spoilage and disease causing microorganisms. Such heat treatments also produce a number of undesirable chemical and textural changes in the vegetables. The textural changes are due to partial destruction of the cell wall and cell membrane. Heat treatments also cause chemical alteration of the green pigment chlorophyll, thus resulting in a process vegetable with less green color. It is important for the food processor to control pH of the water added to the vegetables prior to canning. Most processes require that the pH be near neutral (about 6 to 7) to minimize the above adverse chemical reactions that cause loss of texture and color acceptability of the canned green vegetable.

pH Definition

There are a number of definition of pH, but for our purposes the degree of acidity or alkalinity of a solution is usually measured in terms of the pH scale. A neutral solution (contains equal concentrations of acid and alkali) has a pH of 7. Acidic solutions have pH values below 7 and alkaline solutions have pH values above 7. the lower the pH values, the stronger the acid concentration and the higher the pH values above 7, the stronger the alkali concentration in the solution.

EXPERIMENTAL

In this experiment you will investigate the effect of heat and pH upon the color and texture of green beans. The pH of the solutions will be adjusted to alkaline and acidic conditions, but the heating time and all other conditions will be held constant.

Materials

1. Frozen green beans
2. Dilute HCl solution (0.01N HCl)
3. Dilute NaOH solution (0.01N NaOH)
4. Distilled water or tap water

Equipment and Supplies

1. Bunsen burner
2. Timer or wall clock
3. 250 ml beakers with watch glasses
4. 100 ml graduated cylinders
5. Weighing balance
6. 12 - 15 cm filter paper discs
7. Stirring rods
8. Heat resistant gloves or tongs
9. Spatula or table fork
10. Litmus paper strips or pH indicating paper
11. Marking pen

Procedure:

1. Label four beakers, cylinders and filter paper discs:
    1) 0.01N HCl
    2) 0.01N NaOH
    3) Heated control (distilled or tap water)
    4) Unheated control (distilled or tap water)
2. Weigh about 20 grams of green beans into each of the four beakers.
3. Add 100 ml of the above solutions or water to the labeled beakers.
4. Cover the beakers with a watch glass. Stir occasionally with glass rod.
5. Heat each of the beakers to maintain a slow boil (simmer) for exactly 15 minutes. Do not heat the unheated control!
6. Observe and record changes in the appearance of the beans and the solutions in each beaker during the heating treatment.
7. Allow the beakers to cool and then drain the solutions into the labeled graduated cylinders. Drain the unheated control beaker into the labeled graduated cylinder.
8. Pour the drained beans onto the corresponding labeled filter paper discs.
9. Determine and record the pH of each cooling solution and also of the water in the unheated control in the table provided.
10. Observe and record the color characteristic and also the color intensity for each drained solution.
11. Observe the changes in texture (firmness) of each of the green beans by crushing of cutting them with your spatula or table fork. Record these data also in the table provided.

QUESTIONS

What is the temperature of water used for heating the beans in your experiment? How does this temperature compare with that used for commercial processing of vegetables?

Which of your solutions were near neutral? acidic? alkaline?

Which pH solution provided the best color and texture retention?

Which pH solution provided the poorest color retention?

What pigment is responsible of the observed changes in color of the cooked vegetables?

What reactions are responsible for loss of texture in cooked green beans?

DATA TABLE

TREATMENT	pH	COLOR				TEXTURE (1 TO 10)
		DRAINED SOLUTION		DRAINED BEANS		
		CHARACTERISTIC	INTENSITY SCALE (0 TO 10)	CHARACTERISTIC	INTENSITY SCALE (0 TO 10)	
UNHEATED CONTROL						
HEATED CONTROL						
ACETIC ACID						
SODIUM BICARBONATE						

WEEK 2: AVIONICS / HYDRAULICS

1. Introduction
   weight vs. mass
   Gravitational Acceleration Experiment
      - definition of g, velocity, acceleration
      - measuring
      - converting metrics

2. Projectile motion - horizontal projection
   Projectile motion - vertical component projection
      - equations
      - gravity
      - distance, velocity, acceleration
      - vectors - introduce

3. "Pressure in Fluid Systems"
   from C.O.R.D. Materials (Unit 1, p.43)
   VIDEO
   EXPERIMENT
      - specific gravity
      - definition of hydraulic, pneumatic
      - density
      - buoyant force
      - equation work
      - manometer

4. "Energy Stored in a Hydraulic Accumulator"
   from C.O.R.D. Materials (Unit 5, p.37)
   VIDEO
   EXPERIMENT
      - definition of hydraulic accumulator, energy
      - effect of accumulators
      - effect of pressure pulses

Energy Stored in a Hydraulic Accumulator

Lab 5MF2

LAB OBJECTIVES

When you've finished this lab, you should be able to do the following:

1. ***Describe how a hydraulic accumulator absorbs and releases energy within a hydraulic system.***
2. ***Describe the effect of accumulators in systems where sudden changes in pressure occur.***
3. ***Set up a hydraulic system with an accumulator. Measure the effect of pressure pulses in the system with and without the accumulator.***

LEARNING PATH

1. ***Preview the lab. This will give you an idea of what's ahead.***
2. ***Read the lab. Give particular attention to the Lab Objectives.***
3. ***Do lab, "Energy Stored in a Hydraulic Accumulator."***

MAIN IDEAS

- ***Accumulators store fluid potential energy for future use in fluid systems.***
- ***Accumulators decrease and "smooth out" pressure fluctuations in hydraulic systems.***

A **hydraulic system** is any fluid system that uses a liquid as its main working fluid. Some hydraulic systems use a device called an "accumulator." The accumulator is an energy-storing device. Basically, an accumulator is a sealed tank that holds fluid under pressure. One function of the accumulator is to store pressurized fluid in its tank. That way, the fluid is available, on demand, to provide a brief flow in the hydraulic system at a later time.

Hydraulic systems are sometimes subjected to sudden increases in pressure—referred to as **pressure spikes.** Accumulators absorb or dampen these jolts of pressure in a hydraulic system. Many different types of accumulators are made. Five of the most common accumulators are shown in Figure 1.

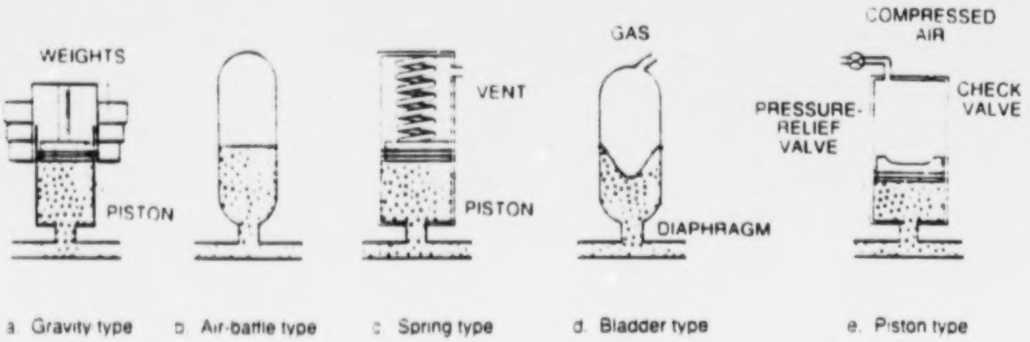
WEIGHTS
PISTON
VENT
PISTON
GAS
DIAPHRAGM
COMPRESSED AIR
CHECK VALVE
PRESSURE-RELIEF VALVE
a. Gravity type
b. Air-baffle type
c. Spring type
d. Bladder type
e. Piston type

Fig. 1 Types of accumulators.

WHAT ARE SOME COMMON USES FOR ACCUMULATORS?

Some types of hydraulic systems use energy at a steady rate. The pump and other parts of those systems are selected to meet a steady demand. One "steady-state" hydraulic system is the water-supply system in your home or school.

You may have noticed that when a water faucet is turned off quickly, often you can hear the water pipes rattle. That rattle is called "water-hammer." The pipes rattle because they're jolted by a pressure spike that develops when the water valve is closed quickly. The pressure spike occurs when the flow of water is stopped too suddenly. Plumbers sometimes install an accumulator in a water system to prevent water hammer. The accumulator absorbs the pressure pulse, converts it into potential energy, and then gradually releases the potential energy back into the system.

Other types of hydraulic systems use energy intermittently. ("Intermittently" means to start and stop, over and over.) An example of this type of system is the air-operated brake system used on a bus or large truck. (See Figure 2.)

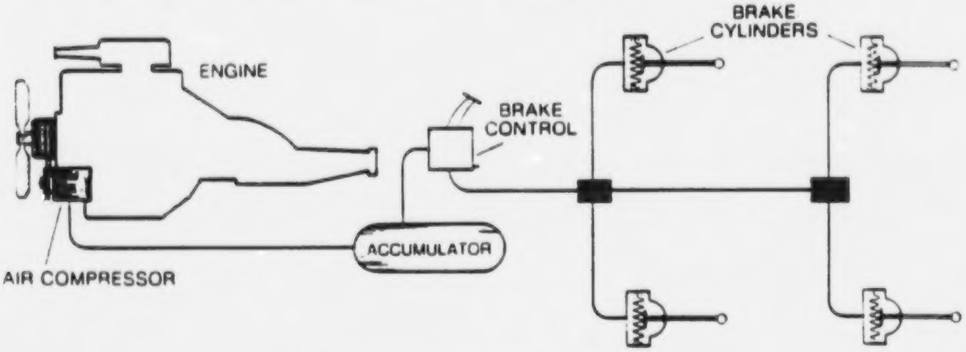
ENGINE
BRAKE CONTROL
BRAKE CYLINDERS
ACCUMULATOR
AIR COMPRESSOR

Fig. 2 Accumulator in an air-operated brake system.

In an air-brake system, the brake pad movement is controlled by air-driven cylinders. An air compressor, powered by the truck engine, supplies pressurized air to the cylinders. However, a large and expensive air compressor would be needed to supply enough air to operate all of the cylinders at the same time.

The problem is solved by using a small compressor and an accumulator in the system. The accumulator stores a large volume of pressurized air. The volume is large enough to operate all the brake cylinders at the same time. Many mechanics call the air storage tank a "reservoir." But they would be more correct to call it an "accumulator."

Some internal combustion engines use turbochargers that boost the engine's efficiency. (See Figure 3.) Bearings in the turbocharger are lubricated by the engine oil pump. When the engine is turned off, the turbocharger turbine continues to turn for a few seconds. During that time, the bearings aren't lubricated because the oil pump is not operating. Some engine manufacturers solve this problem by using an accumulator that sends a flow of pressurized oil to the turbocharger for a few seconds. In this situation, oil in the accumulator is available "on demand" to lubricate the turbocharger bearings.

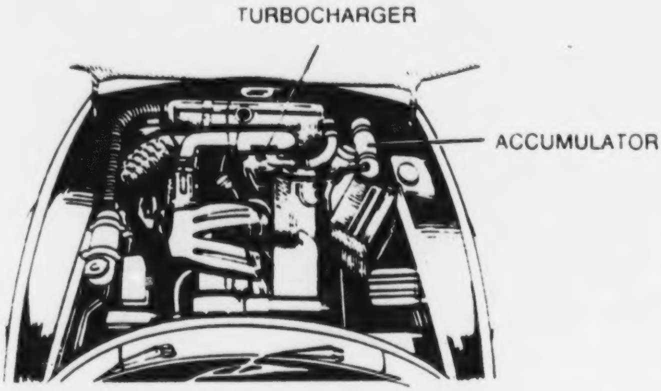

Fig. 3 Accumulators are used to provide proper lubrication.

SOME TIPS ABOUT THIS LAB ...

In this lab, you'll see how a hydraulic system is affected by an accumulator. A shock assembly is connected to an open hydraulic system. The hydraulic system contains an accumulator. When the shock assembly is struck a blow a "pressure spike" travels through the fluid system. The effect of the accumulator on the pressure spike can be investigated. Figure 4 shows the pressure spike in an open fluid system. The large spike on the left indicates a pressure pulse (about 20 psi) traveling through the fluid system without an accumulator in the system. The smaller spike on the right indicates the pressure pulse (about 5 psi) after it has passed by an accumulator placed in the system.

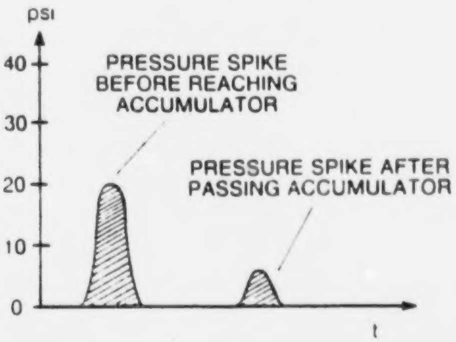

Fig. 4 Effect of accumulator on pressure spike.

LABORATORY

EQUIPMENT

Hydraulic-shock device (vendor supplied), including
- Schedule-40 PVC pipe
- Pipe tee with fitting for pressure gages, two
- Flow-control valves, two
- Accumulator assembly
- Support frame and rubber mallet
- Connector to fluid reservoir

Pressure gage, two, compound type, 15 mm Hg vacuum to 30 psi pressure
Funnel
Large fluid reservoir with porthole on side, near bottom

PROCEDURES

Part A: *Setting Up the Equipment*

1. Study Figure 5. The pipe assembly, from rubber diaphragm to porthole in bucket, is generally mounted on a board. The support frame for the rubber mallet is attached—or can be attached—to the board, as shown in the exploded view.
2. Before beginning assembly, fill the fluid system—from rubber diaphragm to valve #1—with water. To do this, open valve #1, CLOSE valve #2 near the accumulator, and place the pipe assembly, with rubber diaphragm down, in a vertical position. (Place the assembly in a sink or 5-gallon container to control water spills. A funnel can be used, if desired.) Pour water in the end near valve #1 until the assembly is filled. Then close valve #1. (Filling the system in this manner drives air out of the pipes, etc., and ensures that no air pockets are trapped inside.)
3. With valve #1 still closed, place the pipe assembly in a horizontal position on the lab table and connect the pipe assembly to the 5-gallon container. Attach the suspension frame with rubber mallet to the pipe assembly board. The center of the mallet head should line up with the center of the rubber diaphragm, and the face of the mallet head should cover most of the rubber diaphragm when the two are in contact. Be sure the alignment is correct.
4. Pour water into the 5-gallon container until the water level rises about 2 inches—no more—above the center of the pipe assembly. See Figure 5. Make sure the pipe assembly is watertight before proceeding with the laboratory observations.

Part B: *Observing the Effect of Accumulators.*

1. Open valve #1; leave valve #2 closed. Raise the rubber mallet to a horizontal (90°) position and let it fall. (A pressure pulse is generated when it strikes the rubber diaphragm. The pulse travels rapidly along the pipe and dissipates itself in the 5-gallon tank. There should be no reflected pulse.) Carefully watch pressure gages #1 and #2 at the instant the rubber mallet strikes the diaphragm. Read the maximum pressure (psi) indicated on each as the pressure pulse passes by. Jot down the readings on scratch paper.
2. Repeat Step 1 two more times and record only the ***highest*** pressure readings you observed for the three trials in your Data Table.
3. In Steps 1 and 2, the accumulator was "out" of the system since valve #2 was closed. Now open valve #2, admitting the accumulator to the system. Again raise the rubber mallet to the 90° position and repeat the observations outlined in Steps 1 and 2 above. Record the maximum pressure readings you observed for the three trials in your Data Table.

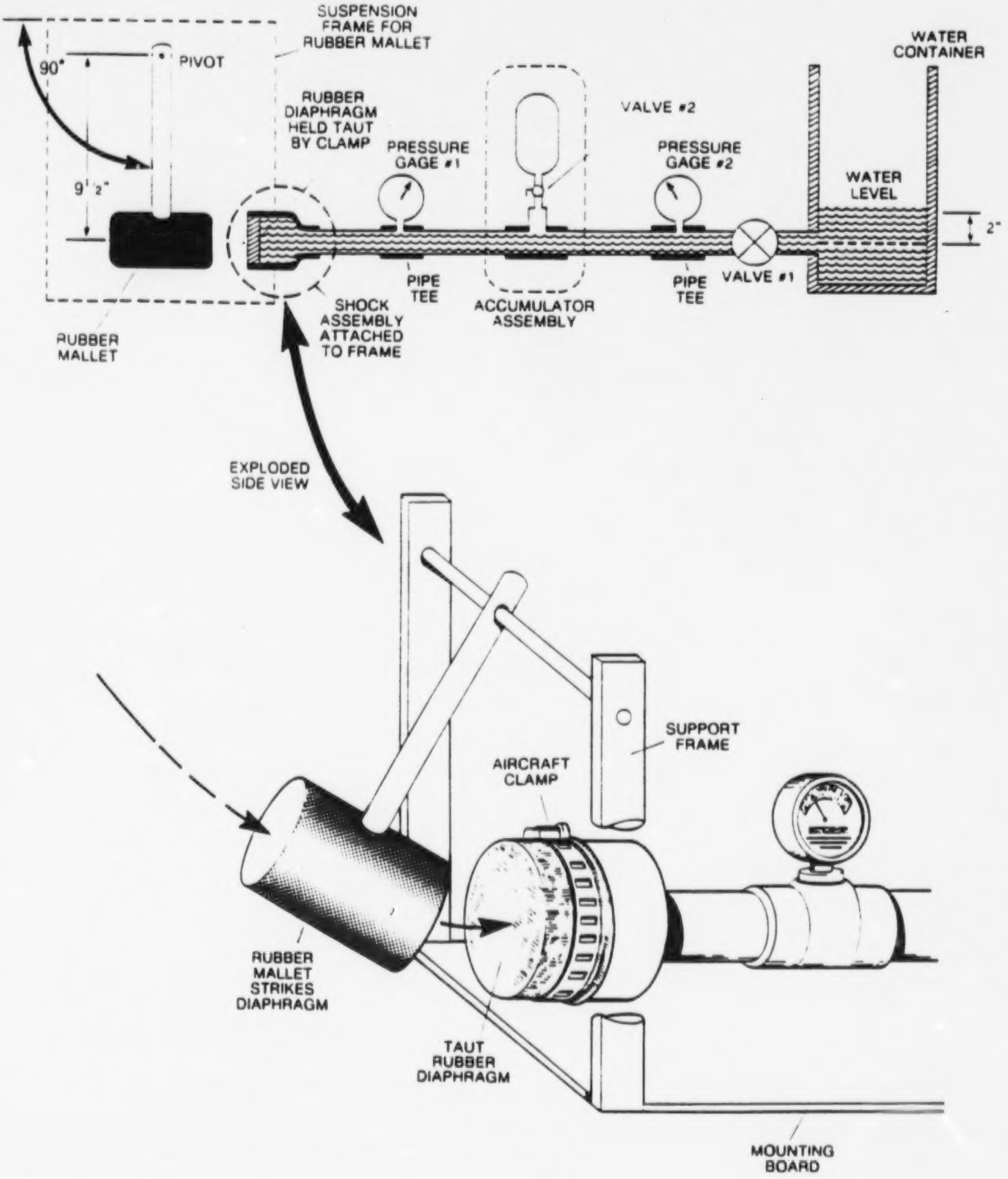
SUSPENSION FRAME FOR RUBBER MALLET
90°
PIVOT
9½"
RUBBER MALLET
RUBBER DIAPHRAGM HELD TAUT BY CLAMP
PRESSURE GAGE #1
PIPE TEE
SHOCK ASSEMBLY ATTACHED TO FRAME
ACCUMULATOR ASSEMBLY
VALVE #2
PRESSURE GAGE #2
PIPE TEE
VALVE #1
WATER CONTAINER
WATER LEVEL
2"
EXPLODED SIDE VIEW
SUPPORT FRAME
AIRCRAFT CLAMP
RUBBER MALLET STRIKES DIAPHRAGM
TAUT RUBBER DIAPHRAGM
MOUNTING BOARD

Fig. 5 Lab setup for hydraulic-shock device.

4. Carefully disassemble the apparatus and empty the pipe assembly and container.

DATA TABLE

Status of Accumulator	Pressure (psi) Gage #1	Pressure (psi) Gage #2
OUT (Valve #2 Closed)		
IN (Valve #2 Open)		

WRAP-UP

1. Describe the observations you recorded in the Data Table and explain the difference in readings, with the ***accumulator out*** and the ***accumulator in***.
2. If air pockets had been trapped in the pipe assembly during filling, how might your final results have been affected?
3. Explain how the presence of an accumulator in the water system in your home would affect "water hammering."

STUDENT CHALLENGE

The pressure pulse (spike) that traveled through the pipe assembly moved at the speed of sound in water. Look up the speed of sound in water and calculate the time for the pulse to travel from pressure gage #1 to pressure gage #2, in your assembly. Does this result explain why both gages indicated pressure readings almost simultaneously after the rubber mallet struck the diaphragm?

Review

1. ***View and discuss the video, "Energy in Mechanical and Fluid Systems I."***
2. ***Review the Objectives and Main Ideas of this subunit.***
3. ***Your teacher may give you a test over Subunit 1, "Energy in Mechanical and Fluid Systems I."***

Measuring Specific Gravity

Lab 1F1

LAB OBJECTIVE

When you've finished this lab, you should be able to measure the specific gravity of a liquid with a hydrometer.

LEARNING PATH

1. ***Preview the lab. This will give you an idea of what's ahead.***
2. ***Read the lab. Give particular attention to the Lab Objectives.***
3. ***Do lab, "Measuring Specific Gravity."***

MAIN IDEAS

- ***The specific gravity of a substance is a number equal to the ratio of the density of the substance divided by the density of water. Basically, specific gravity tells you how the weight of one cubic centimeter of a substance compares to the weight of one cubic centimeter of water.***
- ***Hydrometers measure specific gravity of fluids.***

A hydrometer is an instrument that measures the specific gravity of a liquid. Hydrometers are used widely in industry for four purposes. First, they're used to check on the progress of certain liquid chemical reactions, indicated by a change in specific gravity of the fluid. Second, they're used to determine the composition of a mixture of liquids. Third, they're used to control automatically the blending of lube oils. And fourth, they're also used to measure the difference in density of a liquid, with increase or decrease in temperature.

HOW DOES THE HYDROMETER WORK?

Figure 1 shows a hydrometer. The hydrometer is a glass bulb that has a weight on one end and a scale on the other end. The scale is marked off (calibrated) to show a range of specific gravity values.

When you want to measure the specific gravity of a liquid, you must use the proper hydrometer. For example, the hydrometer used to measure the specific gravity of an acid may not accurately measure the specific gravity of antifreeze.

In order to use a hydrometer, you place it in the liquid. The weighted end sinks in the liquid, but the scale end doesn't. The specific gravity of the liquid will be the reading on the scale that's level with the surface of the liquid. For example, the hydrometer in Figure 1 shows a specific gravity reading of 1.4. The liquid level is at 1.4 on the scale.

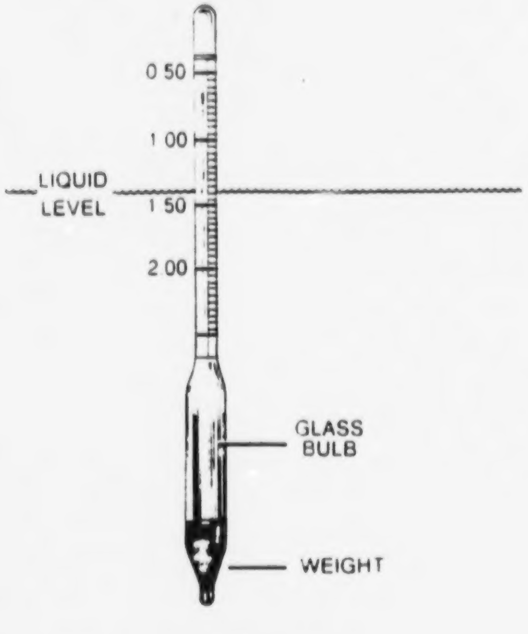

Fig. 1 Hydrometer.

TYPES OF HYDROMETERS

The specific gravity of a liquid is determined by the blend of materials in that liquid. Hydrometers can be used to test the butterfat content of milk, the ethylene-glycol content of antifreeze, or the concentration of impurities in a water sample. Many types of specialized hydrometers are in common use.

A common hydrometer is the storage battery tester similar to the one shown in Figure 2. This is the device you'll use in the lab. It's calibrated to indicate specific gravities between 1.075 and 1.300. When the acid-water mixture in a battery has a specific gravity of 1.26 or greater, the battery is "fully charged." If the specific gravity is lower, the charge is "low." If the charge gets too low, it soon becomes a "dead" battery.

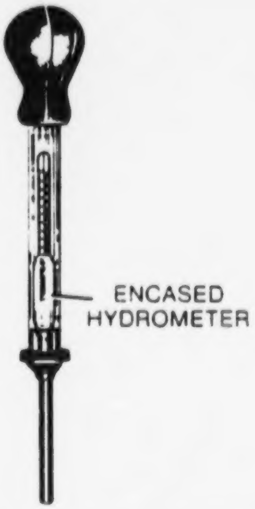

Fig. 2 Battery tester with encased hydrometer.

Another common hydrometer is used to check the temperature protection of antifreeze (ethylene glycol) in the radiator of a car. A mixture of water and antifreeze will freeze at a lower temperature than does water alone. The more antifreeze mixed in with water (up to a mixture of half water, half antifreeze), the lower the temperature can fall before freezing occurs. For example, a car radiator with a 14-quart capacity would be protected to −34°F (its maximum protection) with 7 quarts of water and 7 quarts of antifreeze. Table 1-3 indicates that antifreeze has a higher density than water. This means that the higher the ratio of antifreeze to water in the radiator (up to a half-and-half mixture), the higher the specific gravity. The higher the specific gravity of the mixture, the lower the temperature can fall before the mixture freezes.

LABORATORY

EQUIPMENT

Scaled hydrometer (heavy liquids), 12-in. long, scale 1.000-2.000 in 0.01 div.
Scaled hydrometer (light liquids), 12-in. long, scale 0.700-1.000 in 0.01 div.
Pocket-type hydrometer with colored balls
Standard beaker, 250-milliliter capacity
Four hydrometer jars, 1 ½" × 10" high
Liquid mixtures to include: tap water; isopropyl alcohol; 25% mixture of RV antifreeze (propylene glycol used in ***R***ecreational ***V***ehicles); and 50% mixture of RV antifreeze
Ordinary plastic-type drinking straw (8" × [illegible]/16")

PROCEDURES

Part A: *Measuring specific gravity with commercial hydrometers.*

1. Your teacher will have prepared suitable test liquids—as described under EQUIPMENT—in four hydrometer jars. Unless your teacher has chosen other liquids, the four are isopropyl alcohol, tap water and two mixtures of antifreeze and water. You are to use the appropriate scaled hydrometers provided (one for light liquids and one for heavy liquids) to measure the specific gravity of each test liquid.
2. Carefully place the ***appropriately scaled hydrometer*** in one of the test liquids, making sure that the hydrometer floats. With your eyes at the level of the liquid in the hydrometer jar, read the scale value on the hydrometer at the exact level of the liquid. Read this value to the nearest 0.01 division and record it in the Data Table. **RINSE THE HYDROMETER IN WATER BEFORE USING IT AGAIN.** Repeat this procedure for each of the three other test liquids.
3. Use the pocket-type hydrometer with the colored balls to "measure" specific gravity. Place the sampling tube of the hydrometer below the surface of the first test liquid. Squeeze the bulb and release, thereby causing liquid to be drawn into the chamber that contains the colored balls. Note which, if any, of the colored balls float. Write down your observation in the Data Table. **RINSE OUT THE HYDROMETER THOROUGHLY.** Repeat for the three other test liquids.

DATA TABLE — SPECIFIC GRAVITY

Test Liquid	Scaled Hydrometer	Pocket Hydrometer (Observations)	Homemade Hydrometer
Isopropyl Alcohol			______ Calibration Value
25% RV Antifreeze			
50% RV Antifreeze			
Tap Water			
100% RV Antifreeze			______ Calibration Value

Part B: *Measuring specific gravity with a "homemade" hydrometer.*

1. In this part you will use an ordinary plastic straw to make a crude hydrometer. You will use your hydrometer to make several "rough" measurements of specific gravity. Refer to Figure 3 and follow the simple instructions outlined in the steps that follow.
2. Bend about one inch of the straw up along itself. Hold the "bend" in place with two paper clips. This arrangement must form a tight seal, preventing fluid from entering the straw. (See Figure 3.)
3. Fill a clean, 250-ml beaker about ½ full of *100% RV antifreeze*. Insert the "straw hydrometer" into the antifreeze. Be sure it floats upright, without its bottom end touching the beaker. (See Figure 3.)
4. At the level of the antifreeze, mark a thin, horizontal line on a white portion of the straw. See Figure 3. At this line, the hydrometer should be assigned the specific gravity value for 100% RV antifreeze. You can get this value with one of the accurate, scaled hydrometers.
5. Remove the "straw hydrometer" and wipe off the fluid. (Be sure not to wipe off the calibration line.) Empty the beaker, rinse, and refill with *isopropyl alcohol*, about ¾ full. Reinsert the straw and repeat the procedure outlined in Steps 3 and 4 above. The calibration line established here should be assigned the specific gravity reading for isopropyl alcohol. (See Data Table for value obtained in Part 1.)

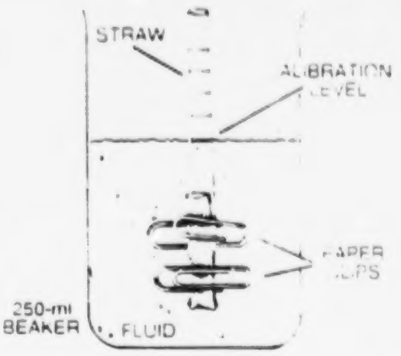

Fig. 3 Homemade hydrometer.

6. Remove the "straw" hydrometer and wipe off the fluid. Divide the space between the two calibration marks on the straw into four equal ***intervals***. Based on the specific gravity values for the two calibration marks, assign values to the three marks in between. *You now have a calibrated, homemade hydrometer.*
7. Empty the beaker, rinse, and refill with a mixture of *50% RV antifreeze*, about half full. Use the homemade hydrometer to measure the specific gravity of the 50% RV antifreeze. You will have to estimate the value, with the help of the scale you established on the straw. Enter the value in the Data Table. Repeat the measurement for tap water. How well does your hydrometer read specific gravity?

WRAP-UP

1. Based on the specific gravity readings obtained in Part 1 with the commercial hydrometers, write down the density (in gm/cm) for each of the five test liquids.
2. List the probable order of the colored balls in the pocket-type hydrometer according to their densities (greatest to least).
3. You found that the hydrometer read a higher value of specific gravity for the 50% RV antifreeze mixture than it did for the 25% RV antifreeze mixture. Explain why.
4. When you look at the scale of a hydrometer, do you find larger values or smaller values of specific gravity at the *lower end*? Explain why this must be so.
5. There are two places in a car where you might need to use a hydrometer to test for specific gravity. Name these places and explain what the hydrometer readings tell you.

BEST COPY AVAILABLE

Measuring Pressure

Lab 1F2

LAB OBJECTIVES

When you've finished this lab, you should be able to do the following:

1. ***Measure pressures above atmospheric pressure with a manometer and a mechanical pressure gage.***
2. ***Measure pressures below atmospheric pressure with a manometer and a mechanical pressure gage.***
3. ***Calculate the absolute pressure, given the gage and atmospheric pressure.***

LEARNING PATH

1. ***Preview the lab. This will give you an idea of what's ahead.***
2. ***Read the lab. Give particular attention to the Lab Objectives.***
3. ***Do lab, "Measuring Pressure."***

MAIN IDEAS

- ***Manometers measure gage pressure and pressure differences between two points in a system.***
- ***Gage pressure, added to atmospheric pressure, gives absolute pressure.***

Manometers are used widely in industry to measure gage pressures and pressure differences between two points in a system. For example, the pressure-difference measurement can show if there's something plugging an air-conditioning duct, or if an air filter is clogged. A manometer can also be used to indicate corrosion buildup in a pipe (which causes reduced flow). Figure 1 shows how a slant-tube manometer—also called an "inclined manometer"—is used to measure pressure drop across a filter in an air duct. If the filter is dirty, the manometer measures a larger pressure drop than if the filter is clean.

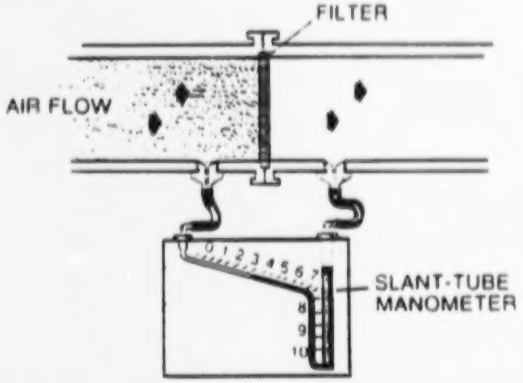

Fig. 1 Manometer used to measure air-pressure drop across a filter.

REVIEW: ABSOLUTE PRESSURE AND GAGE PRESSURE

Absolute pressure is the actual total pressure. A perfect vacuum would have an absolute pressure of zero. Since a perfect vacuum isn't possible, the absolute pressure is always above zero. This means that the absolute pressure is always positive. The absolute pressure of air at sea level is about 14.7 lb/in², 29.92 inches of mercury, 760 millimeters of mercury, or 406.93 inches of water. (Each of these values is equal to the others.) Absolute pressure is used in most scientific pressure measurements.

Most pressure measurements are **gage pressure** readings. **Gage pressure** is the pressure difference between the pressure being measured and atmospheric—or air—pressure. In other words, gage pressure is the difference between the pressure we want to measure and the pressure of the surrounding air. For example, if a tire gage indicates a pressure of 28 lb/in², the pressure in the tire is 28 lb/in² above atmospheric pressure. We can find the absolute pressure by adding the gage pressure and the atmospheric pressure. The absolute pressure in the tire (at sea level) would be about:

$$28\ \text{lb/in}^2 + 14.7\ \text{lb/in}^2 = 42.7\ \text{lb/in}^2$$

In this lab, you'll use a manometer to measure gage pressure. Then you'll add the atmospheric pressure to find the absolute pressure.

REVIEW: HOW THE MANOMETER WORKS

A **manometer** is a device for measuring the difference between two pressures. It's a U-shaped glass tube half-filled with a liquid—usually mercury or water. Figure 2 shows a manometer that's used to measure the pressure difference ($p_2 - p_1$) between two gases.

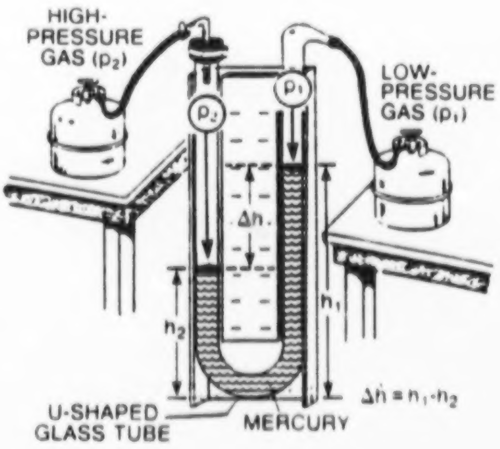

Fig. 2 Mercury manometer for measuring pressure difference.

The pressure difference causes the fluid level to be higher in the low-pressure side of the manometer and lower in the high-pressure side. In Figure 2, pressures p_1 and p_2 are unequal. At the high-pressure side, pressure p_2 is caused by the gas pressure alone. It pushes the fluid level down to a reading shown as h_2. At the low-pressure side, the gas pressure is less. The fluid column here rises to a reading shown as h_1. The pressure difference, $p_2 - p_1$, is proportional to the height difference ($h_1 - h_2$). If the pressure difference between the two gases is increased, level h_2 will drop and level h_1 will rise. Therefore, the difference in heights ($h_1 - h_2$) of the fluid levels also will increase.

A scale is provided to measure the height of the fluid level in each arm. The pressure difference is read off directly as the difference in the two heights. Pressure difference is measured in millimeters of mercury (mm Hg), inches of water (in. H_2O), or centimeters of water (cm H_2O).

The two principal working fluids used in manometers are mercury (Hg) and water (H_2O). Mercury has a density that's 13.6 times greater than the density of water. Therefore, mercury can be used to measure pressures and vacuums on a much shorter scale than water. For example, an atmospheric pressure of 14.7 psi is equal to a column of mercury 29.92 inches tall, or a column of water 406.93 inches tall. (That's 33 feet, 11 inches of water!) So mercury is ideal for measuring large pressure/vacuum ranges, and water is ideal for measuring small value ranges.

HOW DO WE MEASURE PRESSURES ABOVE ATMOSPHERIC PRESSURE?

Figure 3 shows a manometer used to measure a pressure p_B that is above atmospheric pressure. One side of the manometer is open to the atmosphere. The other side is connected to the high pressure (p_B) to be measured. The height difference ($\Delta h = h_1 - h_2$) is the gage pressure expressed in units of length. Thus, the pressure difference ($p_B - p_A$) is proportional to the height difference. To find the absolute pressure, we must add the atmospheric pressure to the gage pressure.

Example A shows how to make this measurement when mercury is used as the working fluid in the manometer and the length measurements are in millimeters.

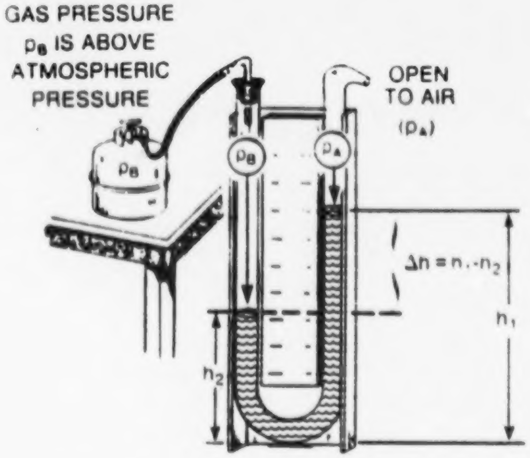

Fig. 3 Manometer indicates a positive gage pressure.

Example A: *Measurement Above Atmospheric Pressure*

Given: In Figure 3, $h_1 = 750$ mm and $h_2 = 250$ mm. The atmospheric pressure is 760 mm Hg.

Find: The gage pressure ($p_B - p_A$) and the absolute pressure (p_B). Give pressure in "height-difference" units.

Solution: Gage Pressure: ($p_B - p_A$) is proportional to ($h_1 - h_2$)
$\Delta h = h_1 - h_2 = 750 \text{ mm} - 250 \text{ mm}$
$\Delta h = 500$ mm Hg (in height units)

Absolute Pressure: p_B = gage pressure + atmospheric pressure
$p_B = 500 \text{ mm Hg} + 760 \text{ mm Hg}$
$p_B = 1260$ mm Hg (in height units)

HOW DO WE MEASURE PRESSURES BELOW ATMOSPHERIC PRESSURE (NEGATIVE PRESSURE)?

Figure 4 shows a manometer used to measure a pressure (p_C) that's below atmospheric pressure (p_A). In this case, the value of $h_1 - h_2$ is negative. Therefore the gage pressure ($p_C - p_A$) has a negative value, telling us that pressure p_C is less than pressure p_A. This pressure may be referred to as "mm Hg of vacuum" or "inches H_2O of vacuum."

Example B shows how to make this measurement. Here, the working fluid is water, and the height measurements are in "centimeters of water."

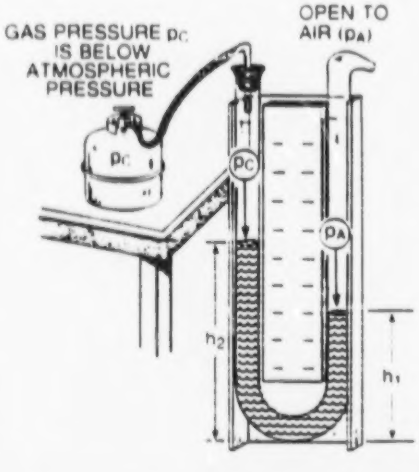

Fig. 4 Manometer indicates a negative gage pressure.

Example B: *Measurements Below Atmospheric Pressure*

Given: In Figure 4, h_1 = 30 cm H_2O and h_2 = 70 cm H_2O. The atmospheric pressure is 75 cm Hg = 1020 cm H_2O.

Find: The gage pressure ($p_C - p_A$) and the absolute pressure (p_C). Give pressure in "height-difference" units.

Solution: Gage Pressure: ($p_C - p_A$) is proportional to ($h_1 - h_2$)

$\Delta h = h_1 - h_2$

Δh = 30 cm − 70 cm

Δh = −40 cm H_2O

The gage pressure is −40 cm H_2O. The negative sign is important. It tells us that the pressure we're measuring is 40 cm H_2O **below** atmospheric pressure.

Absolute Pressure: p_C = gage pressure + atmospheric pressure

p_C = −40 cm H_2O + 1020 cm H_2O

p_C = 980 cm H_2O (in height units)

You should now be ready to use the manometer to make pressure measurements in the laboratory.

LABORATORY

EQUIPMENT

U-tube manometer, with 1-meter arms (or longer)
Hand-operated pressure/vacuum pump
Air-chamber assembly with Dwyer Magnehelic differential pressure gage, zero center (*−15 in. H_2O to +15 in. H_2O*)
Tubing for connections

PROCEDURES

Refer to Figure 5 for a diagram of the laboratory setup. It includes the water manometer, air chamber assembly with pressure gage, and hand-operated pump. Be sure the manometer is half-filled with water. Examine the height measurement scales on the manometer (usually in centimeters, with zero reading at the bottom). Also, examine the scale on the differential pressure gage calibrated to read pressure differences, in either *inches H_2O* or *cm H_2O*.

Run 1: Connect tubing between the manometer arm and pressure gage, and between the air chamber and ***pressure port*** on the hand-operated pump. Carefully and repeatedly squeeze the handle on the pump until the needle on the pressure gage reads *10 in. H_2O*. Pinch the tube between the manometer and pressure gage to hold the water levels in the arms steady. With the scale attached to the manometer (or with a separate meter stick) determine the ***water level difference*** ($h_1 - h_2$) in *cm H_2O*. See Figure 5. Record the value in the Data Table. Since water column h_1 is higher than water column h_2, the difference ($h_1 - h_2$) is a *positive number* and represents a *positive gage pressure*. The positive gage pressure tells you that the pump pressure is ***higher than*** atmospheric pressure.

Run 2: Release the "pinch" on the tube and again apply pressure with the pump, until the gage reads *15 in. H_2O*. Pinch the tube to hold the water levels. Measure the height difference ($h_1 - h_2$) and record in the Data Table. ***Carefully and slowly*** remove the tubing end from the ***pressure port*** of the hand pump. What happens to the water levels in the two arms when you do this?

Run 3: Attach the tubing to the ***vacuum port*** of the hand pump. Operate the pump until the gage reads *minus* 10 in. H_2O. Pinch the tube to hold the pressure settings. Read the height difference ($h_1 - h_2$) and record in the Data Table. ***Note:*** In this instance, water level h_1 is lower than water level h_2. Therefore the difference ($h_1 - h_2$) is a ***negative*** number, indicating a ***negative*** gage pressure. The negative gage pressure tells you that the pressure measured with the manometer is ***lower than*** atmospheric pressure. Record ($h_1 - h_2$) as a negative number in the Data Table.

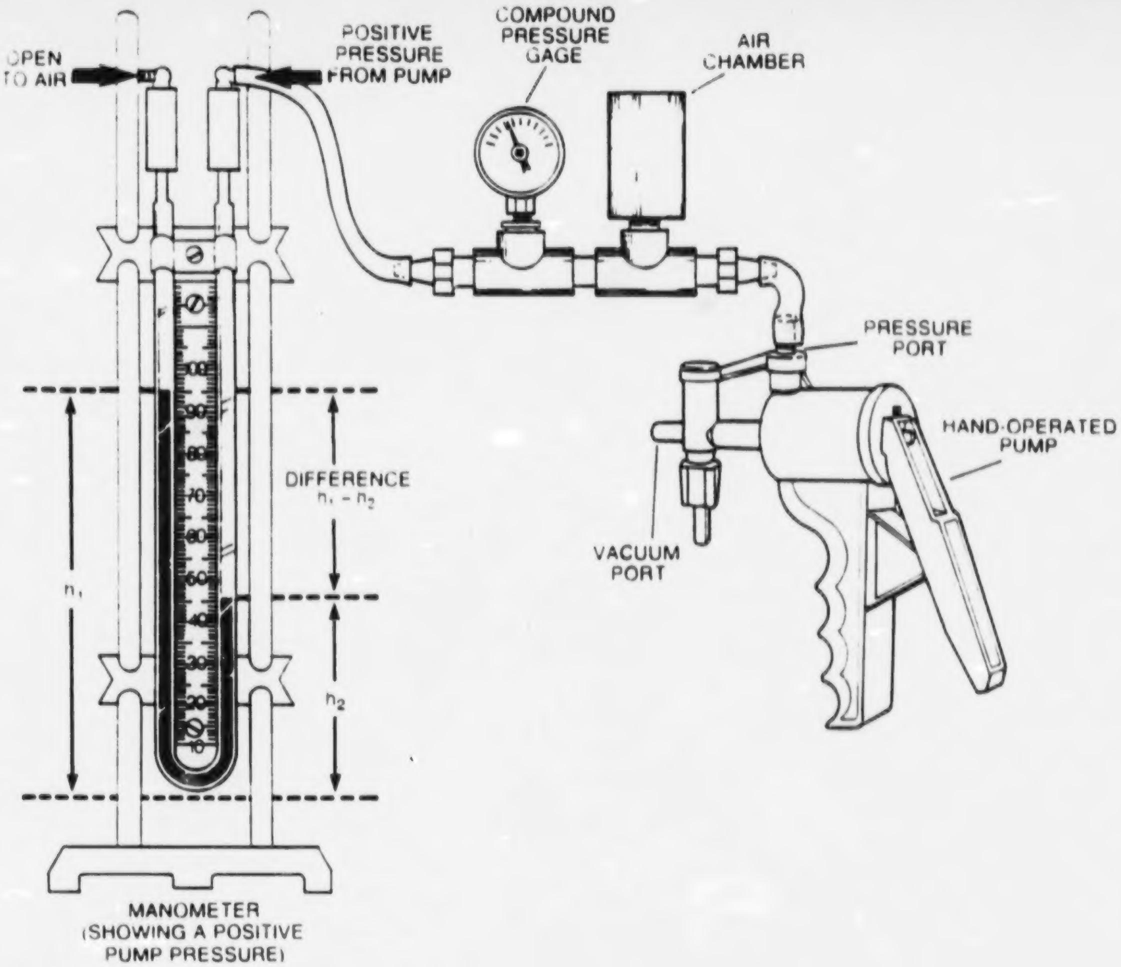
OPEN TO AIR
POSITIVE PRESSURE FROM PUMP
COMPOUND PRESSURE GAGE
AIR CHAMBER
PRESSURE PORT
HAND-OPERATED PUMP
VACUUM PORT
DIFFERENCE $h_1 - h_2$
h_1
h_2
MANOMETER (SHOWING A POSITIVE PUMP PRESSURE)

Fig. 5 Laboratory setup.

Run 4: Repeat the procedure in *Run 3* for a reading on the pressure gage of ***minus*** 15 in. H_2O. Determine the difference in heights of the water levels $(h_1 - h_2)$. Record the negative value for $(h_1 - h_2)$ in the Data Table. Carefully and slowly remove the tubing from the manometer to release the vacuum. Then disconnect the rest of the system and set the parts aside.

DATA TABLE

	Differential Pressure Gage Reading (inches H_2O)	Manometer Gage Pressure $h_1 - h_2$ (cm H_2O)	Manometer Gage Pressure $h_1 - h_2$ (inches H_2O)	Atmospheric Pressure (cm H_2O)	Absolute Pressure (cm H_2O)	Absolute Pressure (psi)
Run 1	+10					
Run 2	+15					
Run 3	-10					
Run 4	-15					

OPTIONAL — WORKING WITH A MERCURY MANOMETER

▲**CAUTION:** ***Mercury is a highly toxic substance that can be absorbed through the skin. Avoid all contact with the mercury liquid. Do not breathe mercury vapors. Always be especially careful when working with, or around, mercury manometers.***

After you have completed your work with the water manometer, your ***teacher may demonstrate*** the use of a mercury manometer. When a mercury manometer is attached to the hand-operated pump, your teacher will show you:

a. how much more pumping is needed to produce a *positive pressure difference* of *10 cm Hg*—as compared with that needed to produce a pressure difference of *10 cm* H_2O.

b. how much more pumping is needed to produce a *negative pressure difference* (vacuum) of *10 cm Hg*—as compared with that needed to produce a negative pressure difference of *10 cm* H_2O.

WRAP-UP

1. Complete column 3 in the Data Table, converting the manometer gage pressure in *cm* H_2O (column 2) to pressure in *inches* H_2O. (***Note***: 1 inch = 2.54 cm.)
2. In the fourth column of the Data Table, enter the value of atmospheric pressure at the time you made the measurements for h_1 and h_2. If you don't know what the true pressure was, ask your teacher. Record value in *cm* H_2O.
3. Calculate the ***absolute pressure*** for each measurement in the Data Table and enter the value in the fifth column of the Data Table. Recall that absolute pressure is obtained by adding the recorded atmospheric pressure to the gage pressure measured by the manometer.
4. Convert the absolute pressure (column 5) in *cm* H_2O to units of *pounds per square inch (psi)*. Use the conversion: *1 cm* $H_2O = 0.0142$ *psi*.
5. For each run, the reading on the differential pressure gage in *inches* H_2O should be equal to the manometer gage pressure (h_1-h_2) in *inches* H_2O. How well did your values in columns 1 and 3 of the Data Table agree?

Student Challenge

1. Consider the difference between the specific gravities of water and mercury. Taking this into account, how tall would the arms of a *water manometer* have to be to measure a pressure difference of *35 cm Hg*? How tall would the arms of a mercury manometer have to be?
2. If you were asked to measure a pressure difference of less than 1 psi—with great accuracy—would you use a water or mercury manometer? Explain why. ***Hint***: Compare the number of "inches of mercury" versus "inches of water" needed to indicate a pressure difference of 1 psi.

SUBUNIT 2

Pressure In Fluid Systems

SUBUNIT OBJECTIVES

When you've finished reading this subunit and viewing the video, "Pressure in Fluid Systems," you should be able to do the following:

1. ***Differentiate between hydraulic and pneumatic systems.***
2. ***Find the density of a substance, given its mass and volume.***
3. ***Determine the specific gravity of a substance, given its density and the density of water.***
4. ***Define buoyant force in one or two sentences.***
5. ***Define pressure. Identify it as a vector or scalar quantity.***
6. ***Explain where atmospheric pressure comes from. State the sea level standard value for atmospheric pressure in the appropriate system of measure.***
7. ***Find pressure, force or area, using the formula,*** $p = {}^{F}\!/_{A}$, ***given any two of the quantities in the formula.***
8. ***Describe the difference between absolute and gage pressure.***
9. ***Explain how pressure in a fluid depends on depth of fluid.***
10. ***Solve for one quantity, given the other two, in the following equation:*** $p = \rho_w \times h$.
11. ***Describe how fluid pressure is a forcelike quantity.***
12. ***Given a fluid system with two connected reservoirs, describe fluid levels in each reservoir that will cause fluid motion between reservoirs, or that will cause no motion.***
13. ***Explain how manometers are used to measure pressures.***
14. ***Describe how a technician might have to measure and/or control pressure in a fluid system.***

LEARNING PATH

1. ***Read this subunit. "Pressure in Fluid Systems." Give particular attention to the Subunit Objectives.***
2. ***View and discuss the video. "Pressure in Fluid Systems."***
3. ***Participate in class discussions.***
4. ***Watch a demonstration about pressure.***
5. ***Complete the Student Exercises.***

MAIN IDEAS

- ***Hydraulic systems use liquid: pneumatic systems use gas.***
- ***Pressure difference can cause fluids to move along pipes.***
- ***Gage pressure equals total pressure minus atmospheric pressure.***
- ***Atmospheric pressure is dependent upon distance above sea level.***
- ***Pressure in fluids increases with depth of fluid.***
- ***Liquids are incompressible and transmit pressure equally in all directions.***
- ***Manometers measure fluid pressure.***

In modern industries, fluid systems frequently are used to drive robots and circulate cooling liquids. They're also used to operate brakes and lubricate moving parts with oil. In an automobile engine, rapidly burning gases in cylinders cause high pressures that move pistons. A technician must understand fluid systems to be able to measure pressures in order to operate or maintain modern equipment.

A ***fluid*** is a ***gas*** or ***liquid*** that conforms to the shape of its container. In a car, antifreeze mixtures, brake fluid, lubricating oils and gases in cylinders are examples of fluids. A ***hydraulic system*** is a fluid system that uses a liquid as the fluid. A ***pneumatic system*** is a fluid system that uses air or gas as the fluid.

Air-conditioning systems use fluids to control temperature and humidity in homes, offices and factories. They operate by using fans to create pressure in ductwork that circulates air through buildings. City water systems are important fluid systems (Figure 1-23) made up of elevated water tanks, underground pipes, water meters, house plumbing and faucets.

In air-conditioning systems, the fluid is air. In city water systems, the fluid is water.

DENSITY, SPECIFIC GRAVITY AND MASS—PROPERTIES OF FLUIDS AND SOLIDS

Have you ever wondered why motor oil floats on water? Or why a balloon filled with hot air rises? The answer is found in a property of materials called ***"density."*** The density of a substance is the mass of that substance divided by the volume of that substance. See the following equation:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$D = \frac{M}{V}$$

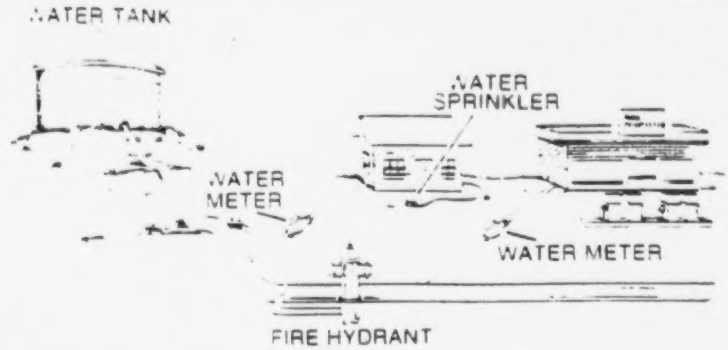

Fig. 1-23 A city water system depends on pressure to move water.

Density is expressed in units of mass divided by units of volume. In SI, mass often is measured in kilograms. A smaller unit of mass, called the ***"gram,"*** is also used. A gram is $\frac{1}{1000}$ of a kilogram. It takes about 454 grams to equal one pound of mass. Volume is measured in cubic meters (m^3) or cubic centimeters (cm^3). Thus, in SI, density is expressed in kg/m^3 or in gm/cm^3. In the English system, density is given as pounds mass/volume (lbm/ft^3) or pounds weight/volume (lb/ft^3). If density is given as pounds weight/volume, it's called "weight density." Water is used as a basic reference. In SI units, water has a density of one gm/cm^3. In English units, water has a weight density of 62.4 lb/ft^3.

The ***specific gravity*** of a substance is the density of that substance divided by the density of water. The following equation explains this relationship:

$$\text{Specific Gravity} = \frac{\text{Density of Substance}}{\text{Density of Water}}$$

Since specific gravity is "density divided by density," units cancel out. Therefore, specific gravity is always a pure number. For example, the specific gravity of mercury is 13.6. Table 1-3 lists the density and specific gravity of some common solids and liquids. Note that density always requires units—like gm/cm^3. Specific gravity has the same numerical value as density, for any given substance, but carries no units. For example, copper has a ***density*** of ***8.9 gm/cm^3***, and a ***specific gravity*** of ***8.9.***

TABLE 1-3. DENSITY AND SPECIFIC GRAVITY

	Density	Specific Gravity
Solids		
Gold	19.3 gm/cm^3	19.3
Lead	11.3 gm/cm^3	11.3
Silver	10.5 gm/cm^3	10.5
Copper	8.9 gm/cm^3	8.9
Steel	7.8 gm/cm^3	7.8
Aluminum	2.7 gm/cm^3	2.7
Balsa Wood	0.3 gm/cm^3	0.3
Oak Wood	0.8 gm/cm^3	0.8
Liquids		
Mercury	13.6 gm/cm^3	13.6
Water	1.0 gm/cm^3	1.0
Oil	0.9 gm/cm^3	0.9
Alcohol	0.8 gm/cm^3	0.8
Ethylene Glycol	1.125 gm/cm^3 (32°F)	1.125
(Antifreeze)	1.098 gm/cm^3 (77°F)	1.098

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A typical calculation of density and specific gravity for a certain liquid is shown in Example 1-E.

Example 1-E: *Density and Specific Gravity*

Given: A volume of 500 cm^3 of a certain fluid has a mass of 550 gm.

Find: The density and specific gravity of that fluid.

Solution: Density = Mass/Volume

Density = (550 gm)/(500 cm^3)

Density = 1.1 gm/cm^3

$$\text{Specific Gravity} = \frac{\text{Density of Fluid}}{\text{Density of Water}}$$

$$\text{Specific Gravity} = \frac{1.1\ \cancel{gm/cm^3}}{1.0\ \cancel{gm/cm^3}}$$ (Cancel identical units.)

Specific Gravity = 1.1

The density of the fluid is 1.1 gm/cm^3; the specific gravity is 1.1.

If you know the density and volume of a fluid, you can find the mass of the fluid by multiplying volume times density. See the equation at right. This is shown in Example 1-F.

Mass = Volume × Density

$M = V \times D$

Example 1-F: *Specific Gravity, Density, Volume and Mass*

Given: The fluid in a container has a volume of 400 cm^3 and a specific gravity of 0.9.

Find: The mass of the fluid.

Solution: Since Specific Gravity = 0.9, Density = 0.9 gm/cm^3

Mass = Volume × Density

Mass = (400 cm^3) × (0.9 gm/cm^3)

$$\text{Mass} = (400 \times 0.9)\ (\cancel{cm^3})\left(\frac{gm}{\cancel{cm^3}}\right)$$ (Cancel identical units.)

Mass = 360 gm

WHAT'S BUOYANT FORCE?

When an object floats or sinks in a fluid, there's an upward force on the object that's equal to the weight of the fluid displaced. This upward force is called ***"buoyant force."*** The fluid displaced is the amount of fluid "pushed out of the way" by the object in the fluid. If the density of the object is greater than the density of the fluid, its weight is greater than the buoyant force. So it sinks. For example, iron sinks in water. If the object is less dense than the fluid in which it's placed, its weight is less than the buoyant force. So the object floats. For example, balsa wood floats easily in water. Use Table 1-3 to help you answer this question: "Will lead sink or float in mercury?"

Figure 1-24 shows an object floating in a liquid. The weight of the liquid displaced by the object equals the weight of the object. If the weight of the object increases, it floats lower in the liquid, just as a boat floats lower when

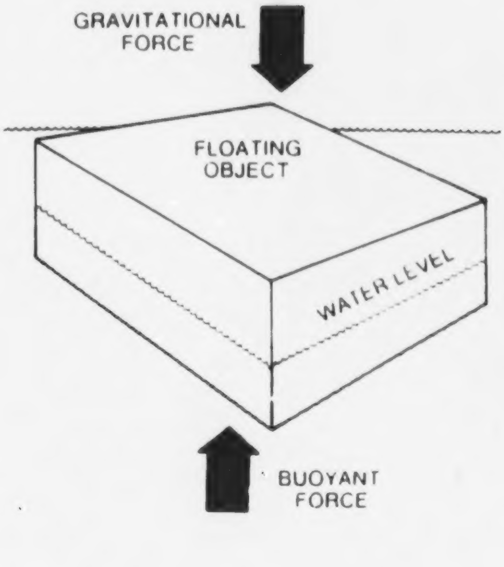

Fig. 1-24 Buoyant force.

loaded. The same object will float higher in liquids of higher density and will float lower in liquids of lower density. This is the idea used in the ***hydrometer***, which is an instrument that measures density or specific gravity of liquids.

PRESSURE IN FLUIDS IS A FORCE PER UNIT AREA.

Pressure is familiar to most of us. We talk about the air pressure required to inflate tires. We know that lawn sprinklers barely "throw out" water when the water pressure is low. Local weather forecasters talk about a "high-pressure" system moving in. In any fluid system, it's a difference in pressure, between separate regions in the fluid systems, that causes fluids to move from regions of high pressure to regions of low pressure.

Pressure is defined as the force per unit area exerted by a fluid—either a liquid or gas. In equation form, pressure is defined as follows:

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

$$p = \frac{F}{A}$$

where: F = force in newtons (N) or pounds (lb)
A = area in square meters (m^2), square inches (in^2) or square feet (ft^2)
p = pressure in N/m^2, lb/in^2 or lb/ft^2

The equation, $p = F/A$, can be rearranged to provide us with the following useful form:

$$\text{Force} = \text{Pressure} \times \text{Area}$$
$$F = p \times A$$

With this equation, if the pressure and area are known, we can find the total force acting on a given surface.

WHAT IS ATMOSPHERIC PRESSURE?

On earth, we live at the bottom of a thick blanket of air. Since air has weight, and the blanket of air is mostly above us, we feel its weight as a pressure pushing in on us from all directions. At sea level, the atmosphere presses on us and everything else with a force of 14.7 pounds for every square inch of body or object surface. At higher altitudes—like the peak of a high mountain—the pressure is a little less. We call the force per unit area of 14.7 lb/in^2 (or 1.013×10^5 N/m^2) the "***atmospheric pressure.***" It acts equally in all directions—upward, downward or sideways. Since pressure does act equally in all directions at any point in a fluid—unlike a force that acts in specific directions—pressure is a ***scalar.*** Pressure is completely described by specifying only its magnitude: no direction is required. Table 1-4 lists units of atmospheric pressure often used in SI and the English system.

TABLE 1-4. UNITS OF ATMOSPHERIC PRESSURE (SEA LEVEL)

1 atmosphere = 14.7 lb/in^2 (psi)*
= 2117 lb/ft^2
= 1.013×10^5 N/m^2 or pascal (Pa)
= 33.92 ft of water
= 760 mm of mercury (760 Torr by international agreement)
= 29.92 in. of mercury

WHAT'S THE DIFFERENCE BETWEEN ABSOLUTE AND GAGE PRESSURE?

When working with fluid systems, pressure measurements often are reported either as ***absolute*** pressure or as ***gage*** pressure. It's important to know the difference. For example, let's think about filling a tire with air. We use a pump which forces more and more air into the tire. As the tire fills up—and the pressure inside increases—the tire takes on a rigid shape. If we check the air pressure with a tire gage, it might read 30 lb/in^2. But what does this reading mean? Is it 30 lb/in^2 gage pressure or 30 lb/in^2 absolute pressure?

To answer these questions, we need several definitions. ***Absolute pressure*** is the ***total pressure*** measured above a reference of zero pressure—a perfect vacuum. ***Gage pressure*** is the pressure measured ***above atmospheric pressure.*** Gage pressure is a measure of how much greater the air pressure inside the tire is ***over*** the air pressure outside the tire. Gage pressure is the total pressure ***minus*** atmospheric pressure. Gage pressure is generally measured with a gage, hence the name, "gage pressure." Total pressure, atmospheric pressure and gage pressure are related in a simple equation, as follows:

$$\text{Total Pressure} = \text{Gage Pressure} + \text{Atmospheric Pressure}$$

The letters, "psi," stand for pounds per square inch.

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Let's bring these ideas together in an example. A tire gage is used to measure air pressure in a tire. It shows 30 lb/in^2—the gage pressure. If the atmospheric pressure equals 14.7 lb/in^2, then the total pressure is equal to:

$$\text{Total Pressure} = 30\ \text{lb/in}^2\ \text{(Gage)} + 14.7\ \text{lb/in}^2\ \text{(Atmospheric)}$$

$$\text{Total Pressure} = 44.7\ \text{lb/in}^2.$$

The trapped air inside the tire pushes out on each square inch of wall surface with a pressure of 44.7 lb/in^2. The atmosphere (air on the outside) pushes in on each square inch of tire wall with a pressure of 14.7 lb/in^2. The difference—30 lb/in^2—is the gage pressure. That's what the gage measures.

The tire gage is a useful pressure-measuring device. Its operation is quite simple. (See Figure 1-25.)

The tire gage is made of a movable bar indicator and coiled spring housed in a cylindrical tube. When the gage is placed over the valve stem of a tire, the gage chamber and tire become sealed. The pressurized air from the tire flows into the gage chamber. This forces the coil spring to compress. As the spring compresses, it pushes the calibrated bar indicator out of the cylinder housing. When the force of the compressed spring equals the force caused by the pressure within the gage chamber, the forces are balanced. The exposed calibrated bar indicates the correct gage pressure—the pressure within the tire.

Let's apply the equation F = p × A, that is, Force = Pressure × Area, to calculate the total force pushing outward on a window of a commercial airplane when the plane is flying at a high altitude. Airplane designers make calculations like the one outlined in Example 1-G. To determine the strength of window material to use, the designers need to know the total force on the window so it can be fastened in place and not be "blown out" of the airplane cabin at high altitudes.

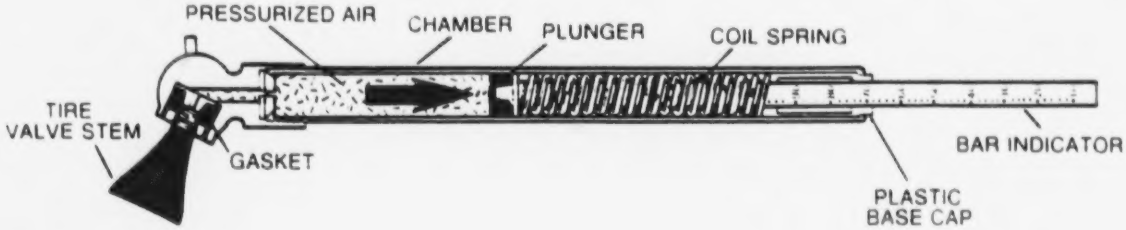


Fig. 1-25 A tire pressure gage measures gage pressure.

Example 1-G: ***Force on an Airplane Window***

Given: An airplane window with a surface area of 144 square inches. Air pressure inside the cabin is 14.7 lb/in^2. Air pressure outside the window is 6.7 lb/in^2.

Find:
a. Force pushing inward on window.
b. Force pushing outward on window.
c. Net force on window.

Solution:
a. Inward force on window

$$F_{in} = P_{in} \times A = \left[6.7\,\frac{\text{lb}}{\cancel{\text{in}^2}}\right](144\,\cancel{\text{in}^2}) = 964.8\ \text{lb}$$

(Cancel identical units.)

b. Outward force on window

$$F_{out} = P_{out} \times A = \left[14.7\,\frac{\text{lb}}{\cancel{\text{in}^2}}\right](144\,\cancel{\text{in}^2}) = 2116.8\ \text{lb}$$

(Cancel identical units.)

c. Net force on window

Net force = Force out − Force in
Net force = 2116.8 lb − 964.8 lb
Net Force = 1152 lb.

The window is being pushed outward with a net force of 1152 lb.

For example, when the plane is flying at 35,000 ft, the atmospheric pressure outside of the plane might be only half as much as sea-level pressure. But inside the plane, for passenger comfort, the cabin is pressurized to near the sea-level value of 14.7 lb/in^2. Thus, a pressure difference exists across the window, with the higher pressure pushing from the inside toward the outside. This causes a net outward push—or force—on the window. In Example 1-G, you worked through a problem showing you how to calculate the net force pushing out on the window.

PRESSURE INCREASES WITH DEPTH

In a water tank, swimming pool or lake, the pressure exerted by the water increases with depth. Let's examine this condition in a swimming pool. See Figure 1-26. The deeper the pool, the more water there is on top of each square inch of the pool bottom. This means that there are more pounds of pressure per square inch on the bottom of the deep end of the pool than at the shallow end.

The swimming pool in Figure 1-26 has a shallow end and a deep end. The shallow end measures four feet deep when filled. The deep end measures eight feet deep. Think about an area of one square inch of the bottom surface at the shallow end and an identical area at the bottom surface at the deep end. There's twice as much water "sitting" on the one-square-inch area of pool bottom at the deep end. Thus, the weight of the water pressing down on the area at the bottom of the deep end is twice the weight that's pressing down on the area of the shallow end. Since pressure is defined as "force per unit area" (and weight is force) the pressure at the bottom of the deep end is twice the pressure at the bottom of the shallow end.

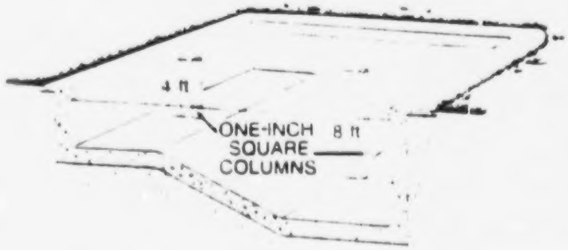


Fig. 1-26 Force per unit area on bottom of pool depends on height of water column above.

The relationship between pressure and depth in a fluid is given by this equation:

Pressure = Weight Density × Fluid Height

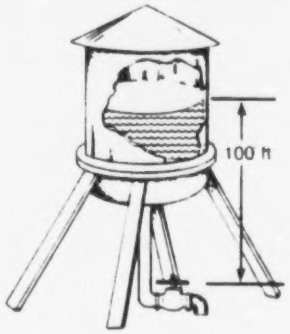
$$p = \rho_w \times h$$

where: ρ_w = weight density in lb/ft^3 (N/m^3 in SI)
h = liquid height in ft (m in SI)
p = pressure in lb/ft^2 (N/m^2 in SI)

Note: "ρ" is the Greek symbol that's pronounced "rho."

Let's use this equation to calculate the water pressure at the bottom of a storage tank. See Example 1-H.

Example 1-H: *Water Pressure Calculation*



Given: The height of the water in a storage tank is 100 ft above a valve. The ***weight density*** of water is 62.4 lb/ft^3.

Find: The pressure at the valve in lb/ft^2 and lb/in^2.

Solution: $p = \rho_w \times h$ Substitute the known values and cancel units, as shown below.

$$p = (62.4\ \text{lb/ft}^3)(100\ \text{ft}) = (62.4 \times 100)\left[\frac{\text{lb}\cdot\cancel{\text{ft}}}{\cancel{\text{ft}}\cdot\text{ft}\cdot\text{ft}}\right]$$

$$p = 6240\ \text{lb/ft}^2.$$

To obtain pressure in lb/in^2, use the conversion, 1 ft^2 = 144 in^2.

$$p = (6240\ \text{lb/ft}^2)\left[\frac{1\ \text{ft}^2}{144\ \text{in}^2}\right] = \left[\frac{6240}{144}\right]\left[\frac{\text{lb}}{\cancel{\text{ft}^2}}\right]\left[\frac{\cancel{\text{ft}^2}}{\text{in}^2}\right] \quad \text{(Cancel units.)}$$

$$p = 43.3\ \text{lb/in}^2\ \text{(psi)}.$$

HYDRAULIC LIFT

A hydraulic lift at the local service station is used to lift cars and trucks off the ground. It works because liquids are incompressible (liquid can't be squeezed into a smaller volume), and liquids transmit pressure equally in all directions over a long distance. The air compressor shown in Figure 1-27 increases the pressure above the hydraulic fluid. This pressure is then transmitted to the bottom surface of the lifting "piston." Because the pressure in the fluid is high, and the area of the lifting piston is large, a large pushing force is exerted on the lifting piston. This force is enough to lift the truck.

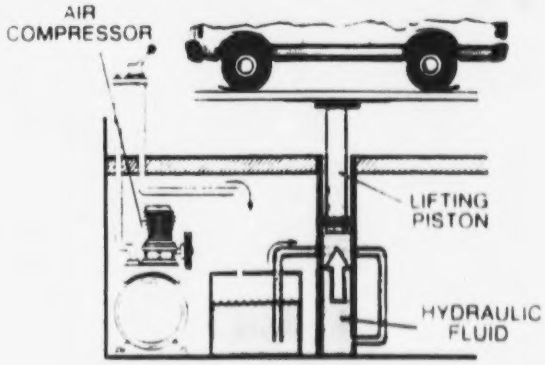


Fig. 1-27 A hydraulic lift.

Example 1-I shows how fluid pressure and lifting force are related in a hydraulic jack.

Example 1-I: *Fluid Pressure in a Hydraulic Jack*

Given: A hydraulic jack is rated at 4000-lb lifting capacity and has a large lifting piston with a diameter (D) of two inches.

Find: Fluid pressure in the jack at maximum load.

Solution: Piston area $A = \pi r^2$, where r is the radius, equal to $^D\!/_2$.

$$\text{Piston area } A = \pi\left(\frac{D}{2}\right)^2 = \frac{\pi D^2}{4} = 0.7854\ D^2$$

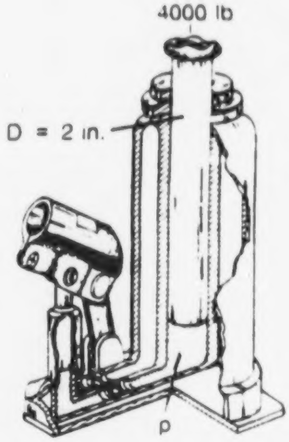
$$A = 0.7854\ (2)^2$$

$$A = 3.14\ \text{in}^2$$

$$p = \frac{\text{Force Applied to Piston}}{\text{Piston Area}} = \frac{F}{A} = \frac{4000\ \text{lb}}{3.14\ \text{in}^2}$$

$$p = 1274\ \text{lb/in}^2\ (\text{psi})$$

Thus, the fluid pressure throughout the inside of the jack, at maximum load, is 1274 psi.



PRESSURES ACT LIKE FORCES

All fluid systems have several things in common. First, each system contains a fluid—either a liquid or a gas—that moves through the system of connecting pipes and devices. Second, a pressure difference in the system causes fluids to move in a given direction or perform some special function—like pushing a piston or opening and closing a valve. In this sense, then, pressure acts like a force when moving a fluid through the system—in much the same way that a mechanical force (a push) moves a box, or a rotational force (a torque) turns a bolt. Pressure is a ***prime mover***.

EQUILIBRIUM IN FLUID SYSTEMS

Liquid or gases move in a fluid system when pressure differences exist between different points in the system. If there's no pressure difference, there's no movement. For this reason, it's *useful* to think of pressure acting like a force in fluid systems. Let's make this point more clear. Figure 1-28 shows two tanks connected by a pipe that contains a gate valve. The pressure at the bottom of each tank is different. That's because the water level in Tank 2 is higher than in Tank 1. Pressure p_2, at the bottom of Tank 2, is higher than p_1, the pressure at the bottom of Tank 1. When the pipe between the two tanks is connected at the bottom of each tank. the pressure on the left side of the valve is p_1 and the pressure on the right side is p_2. Since p_1 is less than p_2. there is a pressure difference across the valve. What happens if the valve is opened?

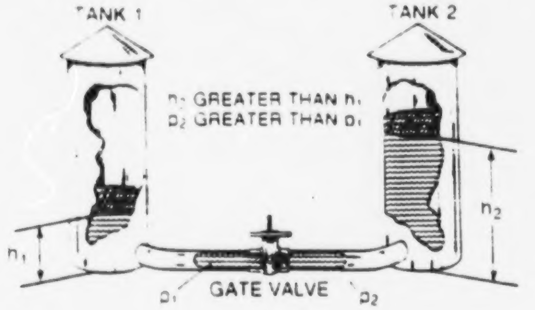


Fig. 1-28 Unbalanced pressures across valve.

Since pressure p_2 is greater than p_1, there will be a force per unit area on the right side of the valve greater than the force per unit area on the left side of the valve. Water then will be pushed through the valve from Tank 2 to Tank 1. Water will flow until the levels in the two tanks are equal. When this happens, pressures p_1 and p_2 will be equal. Then, the system will be in equilibrium. This situation is shown in Figure 1-29.

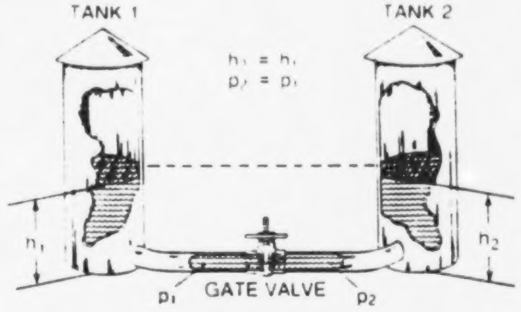


Fig. 1-29 Balanced pressures across valve.

Now consider Figure 1-30. Here, there are two tanks filled to the same level. ($h_1 = h_2$). Tank 2 has a larger diameter than Tank 1, so it contains much more water. But since pressure on the bottom of the tank depends only on height of water contained, the pressure on the bottom of Tank 1 and Tank 2 is the same. Pressure on the bottom doesn't depend on the shape of the tank or the amount of water it contains—just on the height of the water column above the bottom. What happens when the gate valve in Figure 1-30 is opened?

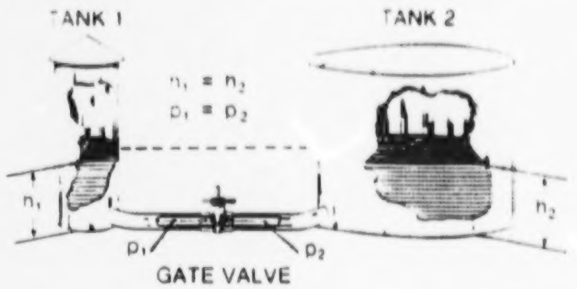
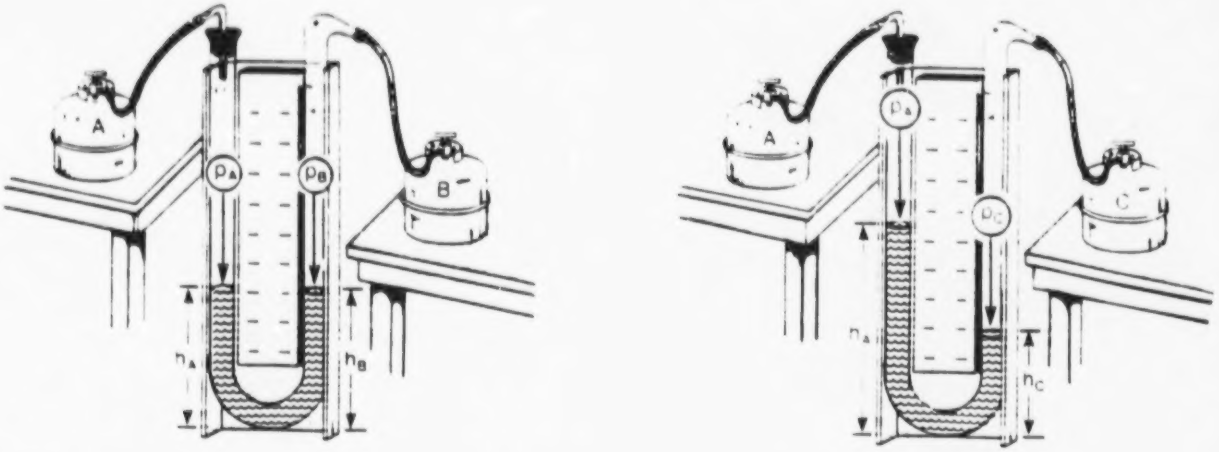


Fig. 1-30 Pressure at bottom does not depend on size of tank.

MEASURING PRESSURES

The same ideas discussed in the illustration of the two tanks connected by a pipe are used in an instrument that measures fluid pressure. This useful instrument is called a **"manometer."** Manometers are used throughout industry to measure gas pressure and pressure difference between two points in a system. For example, measuring pressure difference across a filter in an air-conditioning duct will show if the filter is clean or clogged.

Manometers come in various shapes and often use different liquids (like water or mercury) as indicators. The simplest manometer has a U-tube shape. (See Figure 1-31.) If pressure differences to be measured with the manometer are large, mercury is used as the fluid. If pressure differences are small, water is used as the fluid, since water is much less dense than mercury. Mercury has a weight 13.6 times larger than water. The weight density of water is 62.4 lb/ft^3; the weight density of mercury is 848.6 lb/ft^3. In Figure 1-31a, the gas pressures in containers A and B are equal. Each exerts the same force per unit area on the top surface of the two mercury columns in the U-tube. Since $p_A = p_B$ at the top of each mercury column, the mercury must be at the same level in each arm, so $h_A = h_B$. In Figure 1-31b, the pressure in container C is higher than in container A. Gas C pushes down harder on the right column of mercury than gas A pushes down on the left column. Therefore, the mercury column moves down in the right arm—and up in the left arm. By measuring the difference in height between the two columns of mercury in the U-tube, and using the equation $p = \rho_w h$ (discussed earlier), we can find the difference in pressure between gas A and gas C. Then, if we know the pressure of gas A, we can find the pressure of gas C.


A
B
A
C
p_A
p_B
p_A
p_C
h_A
h_B
h_A
h_C

a. Equal pressures: $p_A = p_B$, so $h_A = h_B$

b. Unequal pressures: $p_A > p_C$, so $h_A > h_C$

Fig. 1-31 Manometers are used to measure pressures.

SUBUNIT 2

Student Exercises

The following exercises review the main ideas and definitions presented in this subunit, "Pressure in Fluid Systems." Complete each question.

1. All fluid systems can be classified as either: (Circle the correct answer.)
   a. solid or liquid.
   b. hydraulic or liquid.
   c. pneumatic or hydraulic.
   d. pneumatic or gas.
2. If 10 cm^3 of a substance has a mass of 105 gm, what is its density?
   a. 1050 gm/cm^3
   b. 1050
   c. 10.5 gm/cm^3
   d. 10.5
3. If the density of a substance is 0.9 gm/cm^3, and water has a density of 1.0 gm/cm^3, the specific gravity of that substance is _____
4. Which of the following is the most complete definition of buoyant force? (Put a check in the correct blank.)
   _____ The apparent weight of an object that floats in water.
   _____ The upward force on an object that is equal to the weight of the fluid displaced by that object.
5. Identify each of the pressure units given below by writing a "p" in the space provided. If it is a pressure unit, note why you know it is.
   a. ft^2/lb ____ ______________________________
   b. lb/in^3 ____ ______________________________
   c. N/m^2 ____ ______________________________
   d. kg/m^2 ____ ______________________________
   e. psi ____ ______________________________
   f. kg/in^3 ____ ______________________________
   g. lb/ft^2 ____ ______________________________
6. A column of air that extends from sea level to the edge of outer space and has a cross-sectional area of one square inch _____ (Circle **each** correct answer that completes the sentence.)
   a. weighs 14.7 lb.
   b. is the cause of atmospheric pressure.
   c. weighs about 2117 lb/ft^2.
   d. weighs the same as a column of water one square inch in cross section, and is 33.92 ft high.
7. Match the following atmospheric pressure value with its respective system of units.
   _____ 760 mm mercury   a. English
   _____ 14.7 lb/in^2 b. SI
8. A tire pressure gage measures air pressure in a 10-speed bicycle tire to be 55 lb/in^2. Atmospheric pressure is 14.7 lb/in^2. The absolute pressure of air in the tire is _____ lb/in^2. The gage pressure of air in the tire is _____ lb/in^2.

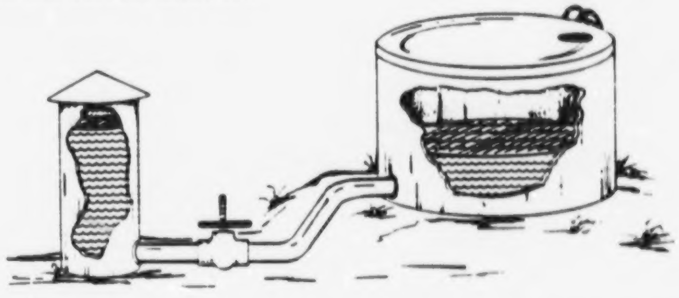
9. A submarine is located at a depth of 100 feet. If a column of sea water one foot high and one square inch in cross-sectional area weighs 0.443 lb, what is the pressure exerted by the sea water on the submarine's hull? (Circle the correct answer.)
   a. 100 lb/in^2
   b. 59.13 lb/in^2
   c. 29.73 lb/in
   d. 44.3 lb/in^2

10. A storage tank is filled to a depth of 25 feet with an alcohol that has a weight density of 58.5 lb/ft^3. What is the pressure at the bottom of the tank? (Remember: $p = \rho_w h$.) (Circle the correct answer.)
   a. 10.2 lb/ft^2
   b. 1462.5 lb/ft^2
   c. 46.800 lb/ft^2
   d. 325 lb/in^2

11. A simple U-tube manometer filled with mercury (ρ_w = 0.49 lb/in^3) is connected between two bottles of gas with different pressures. The difference in height between the two columns of mercury is 14.3 inches. What is the difference in pressure between the two bottles of gas? (Remember: $p = \rho_w h$.) (Circle the correct answer.)
   a. About 7 psi
   b. 29.2 psi
   c. 36.32 mm of Hg
   d. 3.43 in/lb

12. A net pressure is ***like*** a net force in that:
   a. a net pressure causes fluids to move just as a net force causes objects to move.
   b. a sealed container may change its shape due to a net pressure.
   c. a net pressure is measured in units of newtons, just like a force.
   d. None of the above.

13. When the valve is opened between the two tanks shown below, in which direction will the fluid move? (Circle the correct answer.)
   a. The fluid will move from left to right.
   b. The fluid will move from right to left.
   c. The fluid will not move at all.
   d. The fluid will move up in both tanks.



14. The U-tube manometer and spring scale are analogous measurement devices. The spring scale measures _____. The U-tube manometer measures _____. In the spring scale, a spring will stretch a given number of inches for each pound of force applied. In the U-tube manometer, the heights of the columns of mercury will change a given number of inches for each unit of _____.

15. Briefly describe how a technician might measure or control pressure in a fluid system.

Week 2: Aviation/Hydraulics

Monday: Field Trip/Tour: Blackhawk Technical College's Avionics Center
Rock County Airport

Tuesday: Definitions
Lab: "Gravitational Acceleration"
Formulas and Equations

Wednesday: Lab: "Constant Acceleration--Horizontal Projection"
Lab: "Projectile Motion"

Thursday: Demonstration: Fluid properties
Lab: "Archimedes' Principle"

Laboratory: Acceleration of Gravity

Purpose: To demonstrate that gravity gives an object in freefall a constant downward acceleration which can be calculated and compared to the accepted measurement.

Equipment: Freefall apparatus, power supply, spark generator, spark tape, measuring sticks.

Procedure:

1. Adjust the level of the apparatus with the plumb bob so that the weight will fall directly into the cup at the bottom. Let the weight fall a couple of times making sure that the weight falls freely without coming into contact with the apparatus on the way down Then let it fall again with the spark generator turned on to make suer that sparks are produced.

2. Run the tape up the pole of the apparatus along the inside wire and fasten it at the top. Attach the weight. Turn the spark generator on and release the weight. Study the tape to make sure that the sparks made regular marks on the tape. If not, repeat this step until a good tape is produced.

3. On the tape, mark the second spark from the bottom to make sure you do not include any marks made after the weight has struck the apparatus. Remove the tape. (Be careful! The tape is easily marked and it may become very confusing to tell where the spark marks are.)

4. On the tape, starting with the mark you made in step three, count backwards 25 marks, labeling every other mark with a dot or line. Starting with the last mark you made as mark zero, measure the distance between this mark and the next mark. (Measure as accurately as you can.) Record this distance on the worksheet in the distance column on the 0 -1 interval line.

5. Repeat step four for the 1 - 2 interval, 2 - 3 interval, etc. until you have measure and recorded all of the intervals between the labeled marks.

6. The time elapse between each mark should be 1/30th of a second. it may happen that a spark is missed and so the elapsed time for that interval would be 1/15th of a second. This should be easy to discern it it occurs. Record the time for each interval in the t (time) column.

7. The average velocity for each interval can be found by dividing the value in the distance column by the value in the time column. ($v = s/t$) Note that dividing by 1//30th is the same as multiplying by 30. This would be a good time to learn to use the constant multiplier function on your calculator. Record your results on the worksheet.

8. The change in velocity is calculated by subtracting the velocity in one interval from the velocity of the interval below it on the worksheet. For example, to get the change in velocity for the 1 -2 interval, subtract the velocity in the 0 - 1 interval from the velocity in the 1 - 2 interval. You can avoid having to enter the same numbers over and over again by making use of the key on the calculator which exchanges memory with the display.

9. The acceleration is found by dividing the change in velocity by the time interval (again equivalent to multiplying by 30).

10. Add the values in the change in velocity column and divide the sum by 13 (or however many values you have) to find the average change in velocity. Repeat for the acceleration column and record your results. (As a check, multiply the average change in velocity by 30 and see that it equals the average acceleration.)

11. Compare the results you obtained for the acceleration due to gravity with the accepted value of 980 cm/sec^2.

$$\% \text{ difference} = \frac{(\text{Your result} - 980)}{980} \times 100\%$$

12. List possible causes for any differences you may have had on the worksheet.

WEEK 3: ALLIED HEALTH

1. Introduction: VIDEO - " Man the Incredible Machine"
    chemistry demonstration
        - reactions and equations
        - symbols

2. "Chemical Breakdown of Foodstuffs - Enzymatic Action"
    from A & P Lab Book, Lab #40
        - enzymes
        - measuring
        - following directions
        - amylase, maltase, pepsin, etc.
        - measuring temp.
        - lab equipment

3. Gas Laws and Laboratory
    - Boyle's Law
    - Charles' Law
    - measurement
    - cause & effect
    - relating formulas to experimental outcomes

4. Anatomy Overview
    - portions of labs / handouts
    - bones
    - muscle figures
    - microscopes / slides
    - dissected cats

Cat Version

THIRD EDITION

Human Anatomy and Physiology Laboratory Manual

Elaine N. Marieb

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EXERCISE 40

Chemical Breakdown of Foodstuffs: Enzymatic Action

OBJECTIVES

1. To summarize the digestive system enzymes involved in the digestion of proteins, fats, and carbohydrates, and to state their site of origin and the environmental conditions promoting their optimal functioning.
2. To name the end products of digestion of proteins, fats, and carbohydrates.
3. To perform the appropriate chemical tests to determine if digestion of a particular foodstuff has occurred.
4. To cite the function(s) of bile in the digestive process.
5. To discuss the role of temperature and pH in the regulation of enzyme activity.
6. To define *enzyme, catalyst, control, substrate,* and *hydrolase.*

MATERIALS

Supply area 1:
10-ml and 50-ml graduated cylinders
Test tubes and test tube rack
Glass stirring rods
100-ml beakers
Wide-range pH paper
Wax markers
Distilled water
Water bath set at 37° C

Supply area 2:
2% alpha-amylase solution[*]
1% boiled starch solution, freshly prepared[†]
1% maltose solution
1 N HCl and 1 N NaOH in dropper bottles
Lugol's IKI (Lugol's iodine) and Benedict's solutions in dropper bottles
500-ml beaker
Hot plate
Ice bath

Supply area 3:
5% pepsin solution
Alternative substrates:
  Procedure A: albumin solution. Either a 1% solution of commercially made albumin powder or a solution consisting of one part egg white to three parts water
  Procedure B: hard-boiled egg white
2 N HCl and 10 N NaOH in dropper bottles
10% NaOH and 1% $CuSO_4$ in stoppered flasks
Evaporating dishes
Freshly prepared 0.1% Ninhydrin solution
0.1% alcoholic solution of glycine or alanine
Single-edge razor blades

Supply area 4:
2% pancreatin solution in 0.2% Na_2CO_3
Litmus cream (fresh cream to which powdered litmus has been added to achieve a blue color)
0.1 N HCl
Bile salts (sodium taurocholate)
Vegetable oil in dropper bottle

[*] The alpha-amylase should be a low-maltose preparation for best results.

[†] Prepare by adding 1 g starch to 100 ml distilled water; boil and cool; add a pinch of salt (NaCl). Prepare fresh daily.

Since nutrients can only be absorbed when broken down to their monomer forms, food digestion is a prerequisite to food absorption. You have already studied mechanisms of passive and active absorption in Exercise 5. Before proceeding, review that material on pages 29–35.

Enzymes are large protein molecules produced by body cells. They are biologic catalysts, which increase the rate of a chemical reaction without themselves becoming part of the product. The digestive enzymes are hydrolytic enzymes, or hydrolases, which break down organic food molecules by adding water to the molecular bonds, thus cleaving the bonds between the subunits, or monomers.

The various hydrolytic enzymes are highly specific in their action. Each enzyme hydrolyzes only one or a small group of substrate molecules, and very specific environmental conditions are necessary for it to function optimally. Since digestive enzymes actually function outside the body cells in the digestive tract, their hydrolytic activity can also be studied in a test tube. Such an in vitro study provides a convenient laboratory environment for the variation of environmental factors to investigate the effect of such variations on enzymatic activity.

Figure 40.1 is a flow sheet of the progressive digestion of proteins, fats, and carbohydrates, which indicates specific enzymes involved and their site of formation. Acquaint yourself with this flow sheet before beginning this experiment, and refer to it during the laboratory as necessary. Work in groups of four, with each group taking responsibility for setting up and conducting one of the following experiments. Each group should then communicate its results to the rest of the class by recording the results of its experiment in a chart on the chalkboard. Additionally, all members of the class should observe the controls as well as the positive and negative examples of all experimental results. All members of the class should be able to explain the tests used and the results observed and anticipated for each experiment.

STARCH DIGESTION BY SALIVARY AMYLASE

From supply area 1, obtain a test tube rack, 10 test tubes, 10-ml graduated cylinder, wide range pH paper, a glass stirring rod, and wax marking pencils. From supply area 2, obtain a hot plate and a 500-ml beaker, dropper bottles of NaOH and HCl, 40 ml of starch solution, 40 ml of amylase solution, and dropper bottles of Lugol's (IKI) and Benedict's solutions. Two students should prepare the controls (steps 1 to 4) while the other two prepare the experimental samples (steps 5 and 6). Since in this experiment you will investigate the hydrolysis of starch to maltose by **salivary amylase** (the enzyme produced by the salivary glands and secreted into the mouth), it is important to be able to identify the presence of these substances to determine to what extent the enzymatic activity has occurred. Thus controls must be prepared to provide a known standard against which comparisons can be made. (Starch decreases and sugar increases as digestion occurs.)

1. Mark test tube 1 with the wax marker. Place 1 ml of starch solution in the test tube and add two drops of IKI solution. The presence of a blue-black color when IKI is added indicates the presence of starch and is referred to as a **positive starch test.** (As the starch is progressively hydrolyzed, the color with IKI changes from blue-black to blue-red to faint red and then finally disappears when all the starch has been digested.)

2. To obtain a negative starch test, place 1 ml of distilled water in test tube 2, and add two drops of IKI. The unchanged color of the IKI solution indicates the absence of starch. What color did you obtain with water and IKI? ______________________

3. To obtain a **positive sugar test,** obtain and place 1 ml of maltose solution in test tube 3, and add five drops of Benedict's solution. Mix well. Half fill the 500-ml beaker with tap water and start heating it on the hot plate. When the water is boiling, place the test tube in the water bath (the beaker of water on the hot plate) and boil for 5 minutes. The presence of a bright yellow to deep red precipitate (cuprous oxide) indicates a positive test for maltose, sucrose, or any other reducing sugar. (A change to green is also considered a positive test for sugar but indicates the presence of a smaller amount.)

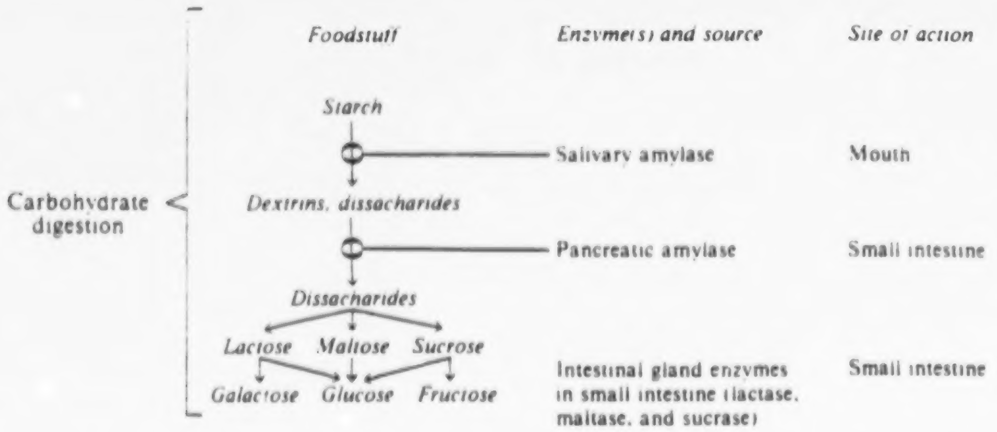
4. To obtain a negative sugar test, place 1 ml of distilled water in test tube 4, add five drops of Benedict's solution, and boil for 5 minutes. If the solution's color remains unchanged from the blue of Benedict's solution, the absence of sugar is indicated.

5. Mark six test tubes with the numbers 5 to 10 and prepare them for incubation as described in the "additives" column of Chart 1 on p. 371. Rinse the stirring rod between samples. Note and record the time that incubation begins in each case, and continually observe the tubes for color changes once the incubation period has started.

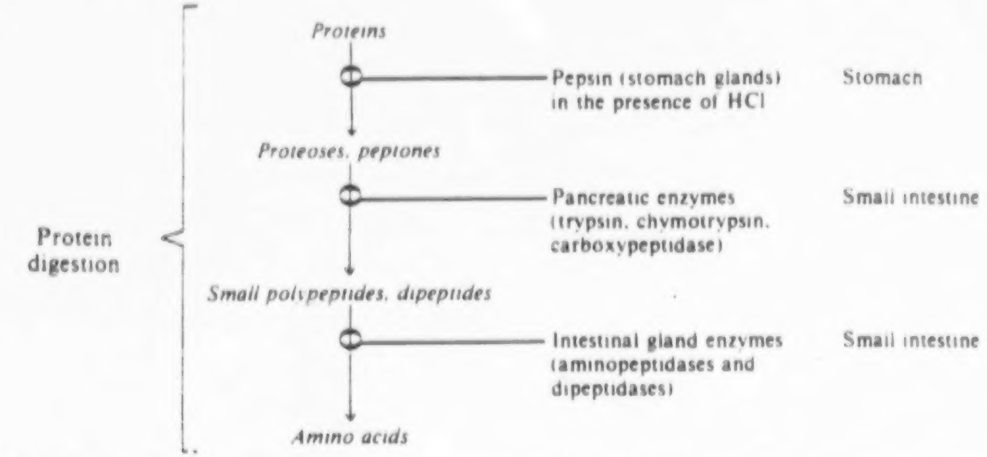
6. As the tubes become colorless (negative starch test), note the time and discontinue their incubation. Perform the *Benedict's test* on each sample. (Add 1 ml of the incubated solution to a clean test tube, and then add five drops of Benedict's solution to the tube. Boil for 5 minutes.) After 1½ hours of incubation, discontinue the incubation of any remaining tubes and conduct the Benedict's test on their contents. Record the results on Chart 1 and on the chalkboard.

PEPSIN DIGESTION OF PROTEIN

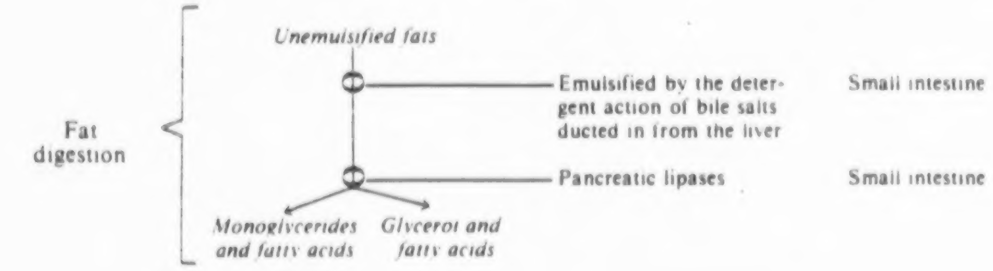
From Supply Area 1, obtain a test tube rack, seven test tubes, a 10-ml graduated cylinder, a glass mixing rod, wax marking pencils, wide range pH paper, plus one of each of the materials/supplies listed under *Supply area 3*. If albumin solution is provided, you will be conducting Procedure A. If hard boiled egg white is provided, follow the instructions for Procedure B.


Foodstuff
Enzyme(s) and source
Site of action
Carbohydrate digestion
Starch
Salivary amylase
Mouth
Dextrins, dissacharides
Pancreatic amylase
Small intestine
Dissacharides
Lactose
Maltose
Sucrose
Galactose
Glucose
Fructose
Intestinal gland enzymes in small intestine (lactase, maltase, and sucrase)
Small intestine

Absorption: The monosaccharides (glucose, galactose, and fructose) are absorbed into the capillary blood in the villi and transported to the liver via the hepatic portal v.


Protein digestion
Proteins
Pepsin (stomach glands) in the presence of HCl
Stomach
Proteoses, peptones
Pancreatic enzymes (trypsin, chymotrypsin, carboxypeptidase)
Small intestine
Small polypeptides, dipeptides
Intestinal gland enzymes (aminopeptidases and dipeptidases)
Small intestine
Amino acids

Absorption: The amino acids are absorbed into the capillary blood in the villi and transported to the liver via the hepatic portal v.


Fat digestion
Unemulsified fats
Emulsified by the detergent action of bile salts ducted in from the liver
Small intestine
Pancreatic lipases
Small intestine
Monoglycerides and fatty acids
Glycerol and fatty acids

Absorption: Absorbed primarily into the lacteals of the villi (glycerol and short-chain fatty acids are absorbed into the capillary blood in the villi). Transported to the liver via the systematic circulation (hepatic artery), which receives the lymphatic flow from the thoracic duct or via the hepatic portal v.

Figure 40.1

Flow sheet of digestion and absorption of foodstuffs.

Chart 1 Salivary Amylase Digestion of Starch

Tube no.	Additives	Incubation condition	Time of initiation	Time for negative IKI test	Benedict's test	
					+	−
5	4 drops IKI; 5 ml starch solution; 5 ml amylase solution	Room temperature				
6	4 drops IKI; 5 ml starch solution; 5 ml amylase solution	37° C				
7	4 drops IKI; 5 ml starch solution; 5 ml amylase solution	0° C (ice bath)				
8	4 drops IKI; 5 ml starch solution; 5 ml amylase solution; boil 4 min before incubating	37° C				
9	4 drops IKI; 5 ml starch solution; 5 ml amylase solution; add 1N HCl until a pH of 3 is achieved (stir after each addition); incubate	37° C				
10	4 drops IKI; 5 ml starch solution; 5 ml amylase solution; add 1N NaOH until a pH of 9 is achieved (stir after each addition); incubate	37° C				

Procedure A:
Two students should prepare the control samples according to the directions in steps 1 and 2 while the other members of the group set up the experimental samples (steps 3 and 4). **Pepsin,** produced by the chief cells of the stomach glands, hydrolyzes proteins to small fragments (proteoses, peptones, and peptides). To identify the extent of protein digestion, prepare controls as standards for comparison. (Protein decreases, and breakdown products such as proteoses and amino acids increase as digestion proceeds.)

1. To prepare a control sample that indicates the presence of protein, perform a *biuret test*. Add 3 ml of 1% albumin solution or egg white to a test tube marked A, and then add 3 ml of 10% NaOH and two or three drops of 1% $CuSO_4$. Mix well with a glass stirring rod. If the mixture turns violet, protein is present. If it does not, continue to add counted drops of $CuSO_4$ to the sample until a violet color appears. *Note the total number of drops used*, and add the same volume of $CuSO_4$ when conducting the biuret test on the experimental samples. A negative biuret test (no color change) indicates complete protein digestion.

2. To prepare a control sample that indicates the presence of amino acids, perform a *Ninhydrin test*. Add 5 ml of 0.1% alcoholic solution of alanine or glycine to a test tube marked B, and then add 0.5 ml of 0.1% Ninhydrin solution, and heat in a water bath.

Record the resulting color. ____________

This color indicates the presence of amino acids (breakdown products of protein digestion).

3. To prepare the experimental samples, mark five test tubes with numbers 1 to 5. Preparation and incubation conditions for the experimental samples are listed below. Determine the pH of each sample *before* adding the albumin solution and record the resultant pH on Chart 2 (p. 372) under the appropriate test tube number in the left column. Place all tubes in the water bath set at 37° C and continue incubation for 2 hours. Shake the tubes occasionally.

4. Perform the biuret test and the Ninhydrin test on two separate samples from each test tube after the 2-hour incubation period. Record the results on Chart 2 and on the chalkboard. (A − indicates a negative test: + indicates a test that is slightly positive: + + indicates a strongly positive test.)

Chart 2 Pepsin Digestion of Protein

Tube no.	Additives	Procedure A						Procedure B Transparency			
		Biuret test			Ninhydrin test						
		−	+	++	−	+	++	−	+	++	+++
1	5 ml pepsin solution; 1 drop 2N HCl; 5 ml albumin solution or 1 slice egg white; incubate at 37° C										
2	5 ml pepsin solution; 1 drop distilled water; 5 ml albumin solution or 1 slice egg white; incubate at 37° C										
3	5 ml pepsin solution; 1 drop 10N NaOH; 5 ml albumin solution or 1 slice egg white; incubate at 37° C										
4	5 ml pepsin solution (boiled); 1 drop 2N HCl; 5 ml albumin solution or 1 slice egg white; incubate at 37° C										
5	5 ml distilled water; 1 drop 2N HCl; 5 ml albumin solution or 1 slice egg white; incubate at 37° C										

Procedure B:
In this procedure, no control samples will be prepared. Instead, extent of protein digestion will be estimated by visual inspection only.

1. Mark five test tubes with the numbers 1 to 5.

2. Using a razor blade, cut five slices of egg white. The slices should be fingernail size and paper thin. The thinness of the egg white is critical to the success of this experiment.

3. The preparation and incubation conditions for the experimental samples are identical to those indicated for Procedure A, except that slices of egg white instead of albumin solution are to be used as the substrate. Determine the pH of each sample *before* adding the slice of egg white, and record it in the left column of Chart 2.

Place all the samples in a water bath set at 37° C and continue incubation for 2 hours. Shake the tubes occasionally, and determine if there is any evidence of digestive activity. The egg white will become increasingly more transparent and will decrease in mass as digestion proceeds.

4. At the end of 2 hours of incubation, observe each sample, and record its relative transparency on Chart 2 according to the following scale:

+++	no egg white observed
++	egg white present, but decreased in mass and very transparent
+	egg white slightly transparent
−	appearance of egg white exhibits no difference from untreated egg white

PANCREATIC LIPASE DIGESTION OF FATS AND THE ACTION OF BILE SALTS

Pancreatin describes the enzymatic product of the pancreas, which includes protein, carbohydrate, and fat-digesting enzymes. It is used here to investigate the properties of pancreatic lipase, which hydrolyzes fats to their component fatty acids and glycerol.

1. From Supply Area 1, obtain a test tube rack, six test tubes, a glass stirring rod, and a 10-ml graduated cylinder. Also obtain one sample each of the substances and supplies listed under *Supply area 4*. One student should prepare the control (step 2), another should set up the demonstration of the action of bile on fats (step 3), while the other two group members prepare the experimental samples (step 4).

Chart 3 Pancreatic Lipase Digestion of Fats

Tube No.	Additives	Incubation Began	Ended	Change in color	Change in odor
2	5 ml litmus cream: 5 ml pancreatin				
3	5 ml litmus cream: 5 ml pancreatin: pinch bile salts				
4	5 ml litmus cream: 5 ml distilled H_2O: pinch bile salts				

2. To prepare the control, add 5 ml of litmus cream to test tube 1. Then add 0.1 N HCl drop by drop (stirring after each addition with a glass stirring rod) until the cream turns pink. This change in color indicates that the test tube contains an acidic product and will identify those tubes in which fat hydrolysis has occurred. (Although fats are not normally considered to be acidic, their hydrolysis products, the fatty acids, are organic acids.)

3. Although bile, a secretory product of the liver, is not an enzyme, it is important to fat digestion because of its emulsifying action (the physical breakdown of larger particles into smaller ones) on fats. Emulsified fats provide a larger surface area for enzymatic activity. To demonstrate the action of bile on fats, prepare two test tubes, and label them A and B. To tube A, add 5 ml H_2O and five drops of vegetable oil. To tube B, add 5 ml of H_2O, five drops of vegetable oil, and a pinch of bile salts. Shake each tube vigorously and allow the tubes to stand in a test tube rack at room temperature for 10 to 15 minutes. Observe both tubes. If emulsification has not occurred the oil will be floating on the surface of the water. If emulsification has occurred, the fat droplets will be suspended throughout the water, forming an emulsion. In which tube has emulsification occurred?

____

4. Prepare the experimental samples as indicated in Chart 3, above. Then shake each test tube well and incubate each in a 37° C water bath until a color change (blue to red) becomes apparent. Note the time incubation begins, the time it ends, and any changes in color and odor of the samples. After 2 hours, discontinue incubation of any samples remaining, regardless of whether a color change has occurred or not. Record results on the chalkboard and in the chart. (If there was no color change, write N.C.)

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STUDENT NAME ______________________

LAB TIME/DATE ______________________

Review Sheet

EXERCISE 40

Chemical Breakdown of Foodstuffs: Enzymatic Action

1. Match the following definitions with the proper key letters.

Key: a. catalyst b. control c. enzyme d. substrate

______________ increases the rate of a chemical reaction without becoming part of the product

______________ provides a standard of comparison for test results

______________ biologic catalyst; protein in nature

______________ substance on which a catalyst works

2. List three characteristics of enzymes. ______________________

____

____

3. The enzymes of the digestive system are classed as hydrolases. What does this mean? ______________________

____

4. Fill in the following chart relative to the various digestive system enzymes encountered in this exercise.

Enzyme	Organ producing it	Site of action	Substrate(s)	Optimal pH
salivary amylase				
pepsin				
pancreatin				

5. Name the end products of digestion for the following types of foods:

proteins ______________ fats ______________ carbohydrates ______________

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6. You used several indicators or tests in the laboratory to determine the presence or absence of certain substances. Choose the correct test or indicator from the key to correspond to the conditions described below:

Key: a. IKI (Lugol's iodine) b. Benedict's solution c. litmus indicator d. biuret test e. Ninhydrin test

____ used to test for the presence of protein, which was indicated by a violet color

____ used to test for the presence of starch, which was indicated by a blue-black color

____ used to test for the presence of fatty acids, which was evidenced by a color change from blue to red

____ used to test for the presence of reducing sugars (maltose, sucrose, glucose) as indicated by a blue to red color change

____ used to test for the presence of free alpha-amino groups as indicated by a blue color

7. In the procedure concerning starch digestion by salivary amylase, how do you explain the fact that neither 0°C incubation nor conditions that involved a preliminary boiling of the enzyme preparation resulted in positive test results for the digestion of starch? ____________________

____

____

What conclusions can you draw when an experimental sample gives both a positive starch test and a positive Benedict's test after incubation? ____________________

____

Why was 37°C the optimal incubation temperature? ____________________

Why did very little, if any, starch digestion occur in test tubes 9 and 10? ____________________

____

____

8. In the procedure concerning pepsin digestion of protein, in which test tube did more protein hydrolysis occur? ________ Why? ____________________

____

Why did test tubes 4 and 5 yield negative results for digestion? ____________________

____

What functional relationship exists between HCl and pepsin? ____________________

____

Pepsin is a protein-digesting enzyme, and the structural material of cells is largely protein. Why doesn't the stomach digest itself? ____________________

____

9. In the procedure concerning pancreatic lipase digestion of fats and the action of bile salts, how did appearance of test tubes A and B differ? ______

______

______

How can you explain this difference? ______

______

Why did litmus cream change from blue to red during the process of fat hydrolysis? ______

______

Why is bile not considered an enzyme? ______

______

______

What role does bile play in fat digestion? ______

______

10. The three-dimensional structure of a functional protein is altered by intense heat or excesses of pH even though peptide bonds may not break. Such inactivation is called denaturation, and denatured enzymes are nonfunctional. Explain why. ______

______

______

What specific experimental conditions in the various procedures resulted in the denaturation of the enzymes?

______

______

11. Pancreatic and intestinal enzymes operate optimally at a pH that is slightly alkaline, yet the chyme entering the duodenum from the stomach is very acid. How is the proper pH for the functioning of the pancreatic-intestinal enzymes assured? ______

______

12. Assume you have been chewing a piece of bread for 5 or 6 minutes. How would you expect its taste to change during this interval? ______

Why? ______

13. Note the mechanism of absorption (passive or active transport) of the following food breakdown products, and indicate (✓) whether the absorption would result in their movement into the blood capillaries or the lymph capillaries (lacteals).

Substance	**Mechanism of absorption**	**Blood**	**Lymph**
monosaccharides			
fatty acids and glycerol			
amino acids			
water			
Na^+, Cl^-, Ca^{2+}			

14. People on a strict diet to lose weight begin to metabolize stored fats at an accelerated rate. How would this condition affect blood pH? ______________________________

____

15. Trace the pathway of a ham sandwich (ham = protein and fat; bread = starch) from the mouth to the site of absorption of its breakdown products, noting where digestion occurs and what specific enzymes are involved.

16. Some of the digestive organs have groups of secretory cells that liberate hormones (parahormones) into the blood. These exert an effect on the digestive process by acting on other cells or structures and causing them to release digestive enzymes, expel bile, or increase the mobility of the digestive tract. For each hormone below, note the organ producing the hormone and its effects on the digestive process. Include the target organs affected.

Hormone	Target organ(s) and effects
secretin	
gastrin	
cholecystokinin	

WEEK 4: MECHANICAL DESIGN

1. Introduction
    - film - "Steel Production" or
      *"Force in Mechanical Systems"

    Experiment:

    Measuring Forces
    from Core Materials (Unit 1, p. 37)

2. Force Table Experiment
    - vectors, resultant, direction
    - trigonometry
    - formulas

3. Thermal Expansion Lab
    - equations
    - temperature measurement
    - length measurement
    - symbolism

4. Film: "Steel Production"
    - wrap-up
    - evaluation

PRINCIPLES OF TECHNOLOGY

UNIT 1
FORCE

SECOND EDITION

Measuring Forces

Lab 1M2

LAB OBJECTIVES

When you've finished this lab, you should be able to do the following:

1. ***Measure forces—in newtons or pounds—by using appropriate scales.***
2. ***Suspend a weight from two cords. Measure the tension (force) in each cord.***
3. ***Make a scale drawing (vector diagram) that illustrates the force in each rope.***
4. ***Use the vector diagram to determine the resultant force.***

LEARNING PATH

1. ***Preview the lab. This will give you an idea of what's ahead.***
2. ***Read the lab. Give particular attention to the Lab Objectives.***
3. ***Do lab, "Measuring Forces."***

MAIN IDEAS

- ***Forces can be measured with devices such as spring scales.***
- ***Forces can be presented visually by using a vector diagram.***

Cables or ropes often are used to lift, pull or suspend heavy objects. When a cable lifts a heavy weight, the force in the cable must not be so great that the cable breaks. By knowing the ***weight*** of the object to be suspended or moved, and the way the cables are arranged to pull on the object, we can calculate the maximum force in the cable. Figure 1 shows how cables (or ropes) can be used to suspend a traffic light at an intersection or lift heavy objects.

Scales are used to measure forces or weights. The amount of force required to balance (hold) the object is just equal to the total weight of the object. Most scales exert a balancing force by stretching springs. Other scales, such as freight scales or those found in department stores, apply a balancing force by compressing springs.

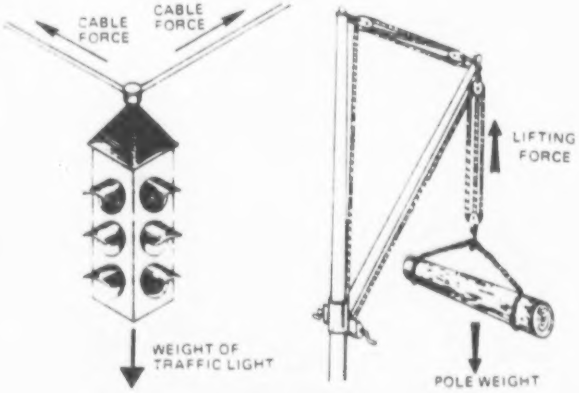

Fig. 1 Forces are used to suspend or move heavy objects

[illegible] ("marked off") to read [illegible] determining the distances that [illegible] stretch or compress the spring. [illegible] mark is made on the scale for [illegible]. Then, when unknown [illegible] from the scales, or placed on [illegible] on the scale indicates the [illegible]

In this lab, you'll suspend a heavy weight between two ropes. Then you'll measure the force (tension) in each rope with a spring scale. You'll also use a protractor to measure the angle formed between the ropes. Then you'll make a drawing that models the data from your measurements. The model will be used to find the resultant force of the two suspending forces.

LABORATORY EQUIPMENT

[illegible] support stand with appropriate attachment points along the top. (This item is supplied by [illegible] and will be used in many laboratories that follow.)
[illegible] spring scales (balances), 0-28 lb
[illegible] mass set that includes various kg masses and a weight hanger
[illegible] lengths 24 inches and 10 inches
[illegible] about 5 feet long
[illegible]
[illegible] centimeter)

PROCEDURES

Part 1 Measuring Forces in Equilibrium

[illegible] Before you begin to set up the [illegible] study Figure 1. There you see a [illegible] support stand, and an arrangement [illegible] scales, cords, and hanging weights. [illegible] arrange your lab equipment similar [illegible] in this figure.

[illegible] hook of one spring scale to [illegible] other device at position A. [illegible] a second spring scale at [illegible] B. Next, tie a single knot at the [illegible] the 24-inch length of cord. [illegible] ends of this cord to the [illegible] the scales attached to [illegible] A and B.

[illegible] cord onto the 24-inch cord [illegible] Be sure it is tied on ***securely***.

[illegible] end of the 10-inch cord to [illegible] the third spring scale. [illegible] hanger to the spring [illegible] carefully place a mass of ***4 kilograms*** [illegible] the hanger.

[illegible] ***horizontally***, from one post [illegible] stand to the other, at the [illegible] knot. Later, this string [illegible] horizontal (level) reference [illegible] angles.

[illegible] setup to that shown in [illegible] should be similar.

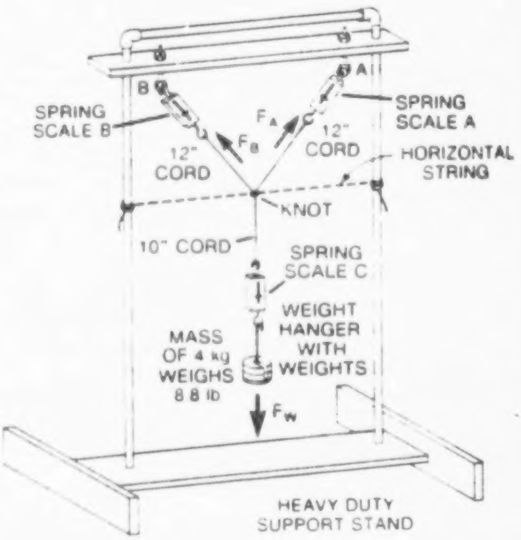

Fig. 1 Lab setup

You are now ready to take data. You will need the spring scales to find the forces along the cords. You will use a protractor to measure certain angles between the cords—to get the directions of the forces.

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6. Look at the drawing in Figure 2. It shows the knot with the three forces pulling on the knot. The forces are labeled F_A (toward position A), F_B (toward position B), and F_W (toward the hanging weight). Also, two angles are shown, angle A (often written as ∠A) and angle B (∠B).

7. Gently pull down about one inch on the 4-kg mass, then let it return to its original position. Now read the force (in pounds) indicated on spring scale A. Write the value down on a piece of scrap paper. Repeat the above procedure two more times, obtaining two more readings. The three readings may all be the same. In any case, record the highest reading you obtained, as F_A, in column 1 of the Data Table.

8. Repeat the procedure in Step 7 for the force indicated on spring scale B. Record the value as F_B in column 1 of the Data Table.

9. Do the same for spring scale C, between the knot and the hanging weight. Record the value as F_W in column 1 of the Data Table.

10. You are now going to use your protractor to measure angles made by the cords. Study Figure 3 before you proceed. Notice that the index point of the protractor must be at the center of the knot, and that the horizontal reference cord must be along the bottom edge of the protractor.

11. Align the protractor carefully—with the knot and the horizontal reference line—as shown in Figure 3. (The horizontal cord should be along the 0° indicators on the protractor.) Holding the protractor steady, read and jot down the angle where the cord attached to spring scale A crosses the protractor. Call this ∠A. Without moving the protractor, read and jot down the angle where the cord attached to spring scale B crosses the protractor. Call this ∠B.

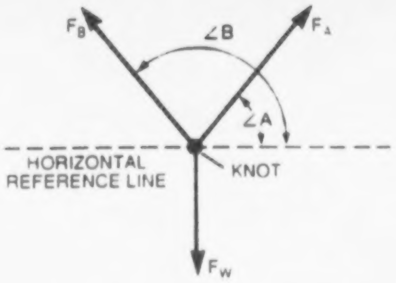


Fig. 2 Sketch of forces and angles.

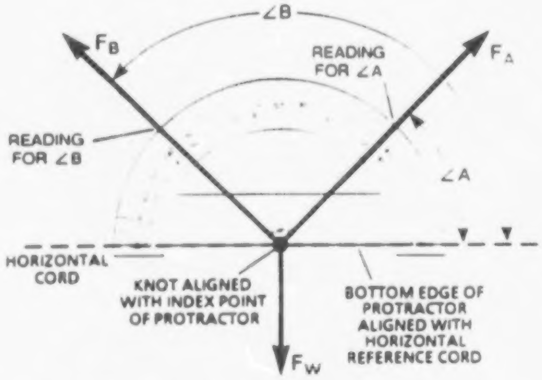

∠B
F_B
READING FOR ∠A
F_A
READING FOR ∠B
∠A
HORIZONTAL CORD
KNOT ALIGNED WITH INDEX POINT OF PROTRACTOR
BOTTOM EDGE OF PROTRACTOR ALIGNED WITH HORIZONTAL REFERENCE CORD
F_W

Fig. 3 Measuring angles with a protractor.

12. Record ∠A and ∠B in column 2 of the Data Table. Notice that ∠A is the angle that force F_A makes with the horizontal reference cord. And ∠B is the angle that force F_B makes with the same reference line. From Figure 3, you can see that the angle between F_A and F_B is just ∠B - ∠A. Call this difference ∠AB and record the value in the Data Table.

DATA TABLE

Column 1	Column 2
Force measure (lb)	Angle measure (degrees)
F_A =	∠A =
F_B =	∠B =
F_W =	∠AB = ∠B - ∠A =

Part 2: Graphical Representation of Forces F_A, F_B and F_W

Now that you've taken your data, it's important that you learn a simple method of analyzing forces. Figure 4a shows a sample Data Table with a typical set of data. (The data you obtained with your setup will probably not agree with the data shown here.) Figure 4b shows the typical values on a sketch of the forces and angles involved in Figure 2.

Now let's analyze the forces by following the step-by-step procedure outlined below. Read through each step carefully, referring to Figures 5a and 5b on the following page. Be sure you understand each step because you will follow a similar procedure with the data you obtained with your setup.

1. Select a plain sheet of paper. You can use a sheet with a grid on it if you wish, but plain paper will work just as well. Based on the values of the forces you measured, select a convenient scale, such as 1 cm = 1 lb, or ½ inch = 1 pound. Think carefully before you choose the scale. If you choose a scale like 1 in. = 1 lb, your drawing may not fit on the page. Or, if you choose a scale like ⅛ in. = 1 lb, your drawing may be too small. For the typical data shown in Figure 4a, we've chosen a scale of 1 cm = 1 lb. As you'll see when you examine Figure 5 that follows, the choice of this scale makes it easy for us to draw large, clear diagrams using most of the page.
2. On the blank page, we first draw a horizontal reference line across the page, through the center. See Figure 5. Near the left edge of this line we draw the vector F_W to represent the hanging weight. Since we hung 4 kg of mass on the hanger (see Figure 1), and each kilogram weighs 2.2 lb (as given in Table 1-1 of the text), we calculate the weight in pounds as follows:

$$4\ \text{kg} \times \left(\frac{2.2\ \text{lb}}{1\ \text{kg}}\right) = \left(\frac{4 \times 2.2}{1}\right)\left(\frac{\cancel{\text{kg}}\cdot\text{lb}}{\cancel{\text{kg}}}\right) = 8.8\ \text{lb}$$

3. Next, using the chosen scale of 1 cm = 1 lb, we draw a line of appropriate length to represent the hanging weight of 8.8 lb. Since the scale is 1 cm = 1 lb, the length is clearly 8.8 cm. For a more "complicated" choice of scale, we could have found the length as outlined here:

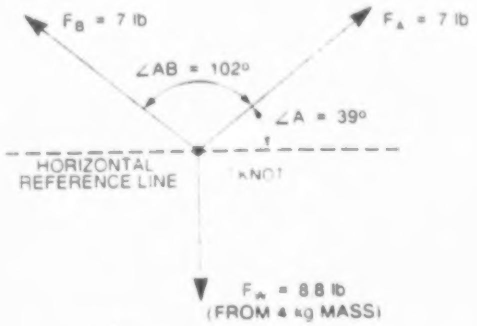
$$8.8\ \text{lb} \times \left(\frac{1\ \text{cm}}{1\ \text{lb}}\right) = \left(\frac{8.8 \times 1}{1}\right)\left(\frac{\cancel{\text{lb}}\cdot\text{cm}}{\cancel{\text{lb}}}\right) = 8.8\ \text{cm}$$

Thus we draw the vector F_W as a line 8.8 cm long, pointing straight down—the same direction that the hanging weight pulls on the knot. The final drawing for vector F_W is shown in Figure 5a.

4. On this same figure, a little to the right of the center point on the horizontal reference line, we make a clear dot to represent the knot. Now, with the help of a ruler and protractor, we draw the vector F_A, beginning at the dot. When completed, the vector F_A must represent a force of 7 lb acting at an angle of 39° above the horizontal reference. From the scale 1 cm = 1 lb, we can see quickly that the 7-lb force F_A should be represented by a line 7 cm long, drawn at an angle of 39°. The tail of the arrow (vector) is at the dot and a neat arrowhead is drawn at the other end of the vector. Figure 5b shows vector F_A.

Forces	Angles
F_A = 7 lb	∠A = 39°
F_B = 7 lb	∠B = 141°
F_W = 8.8 lb (4 kg of mass weighs 8.8 lb)	∠AB = ∠B − ∠A ∠AB = 141° − 39° = 102°

a. Typical values of forces and angles for setup shown in Figure 1

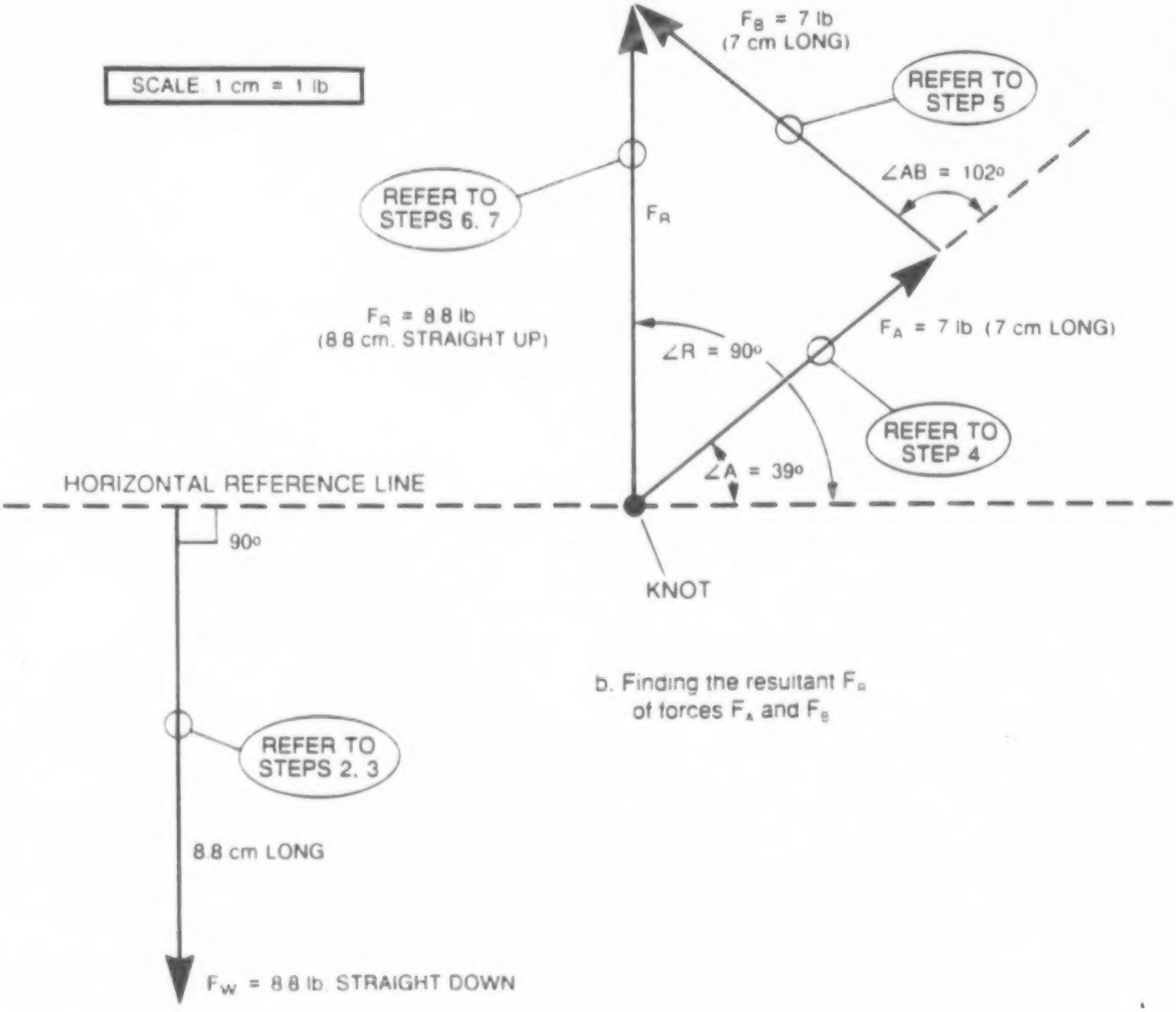


b. Sketch of forces and angles, with typical values

Fig. 4 Data used in sample force analysis

5. Next we extend a dotted line along vector F_A, as shown in Figure 5b. With the index of the protractor located at the tip of vector F_A, and the bottom edge of the protractor along F_A and the dotted line, we measure off ∠AB to be 102°. This is the angle between force F_A and force F_B. See Figure 5b. Then we draw a line along the 102° direction and mark off 7 centimeters. The 7-cm line segment represents vector F_B—7 pounds at an angle of 102° with vector F_A. Figure 5b shows the completed vector F_B.

6. Finally we draw a line from the ***tail*** of vector F_A to the ***head*** of vector F_B, as shown in Figure 5b. This line, F_R, is the ***resultant*** of vectors F_A and F_B. It represents the *single force* that can replace


SCALE 1 cm = 1 lb
F_B = 7 lb
(7 cm LONG)
REFER TO STEP 5
∠AB = 102°
REFER TO STEPS 6, 7
F_R
F_R = 8.8 lb
(8.8 cm, STRAIGHT UP)
∠R = 90°
F_A = 7 lb (7 cm LONG)
REFER TO STEP 4
∠A = 39°
HORIZONTAL REFERENCE LINE
90°
KNOT
REFER TO STEPS 2, 3
8.8 cm LONG
F_W = 8.8 lb, STRAIGHT DOWN

b. Finding the resultant F_R of forces F_A and F_B

a. Drawing the vector F_W

Fig. 5 Drawing the vector diagrams.

(is equivalent to) the separate forces F_A and F_B that hold up the hanging weight.

7. Now we need to find the **magnitude** and **direction** of the resultant F_R. First we use a ruler to measure the length of F_R in Figure 5b. Then we use a protractor to measure ∠R, the angle F_R makes with the horizontal reference. For "good" results the length of F_R should be somewhere between 8.5 cm and 9.0 cm, and ∠R should be close to 90°. For perfect results—shown in Figure 5b but not usually achieved in real laboratory experiments—the length should be exactly 8.8 cm and F_R should point straight up (∠R equals exactly 90°). That's because the resultant vector F_R must be ***equal and opposite*** to the vector F_W. Thus, since F_W is 8.8 cm long and pointed straight down (as we drew in Figure 5a), F_R should be, ideally, 8.8 cm long and pointed straight up.

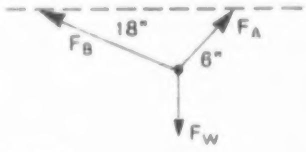
Part 3: *Making a Vector Diagram of Your Data*

Now it's your turn. If you understood the procedure outlined in Part 2, you should not have much trouble making your own vector diagrams.

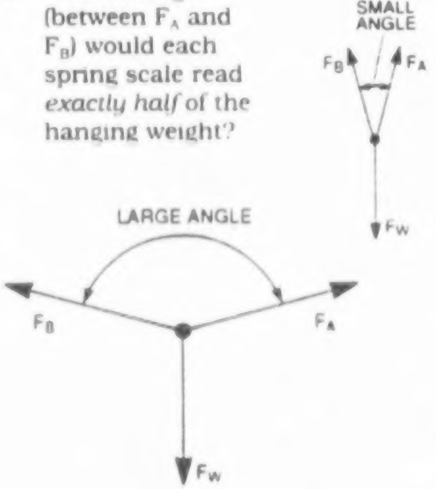
1. Follow the steps outlined in Part 2. Use the data you collected (from Data Table) and make vector diagrams for F_W, F_A and F_B, as was done in Figure 5. Begin with a sheet of plain (or grid) paper.
2. When you finish drawing F_A and F_B, draw the resultant F_R and determine its magnitude and direction as outlined in Part 2. Is your F_R equal and opposite to F_W? If not, can you give reasons why it's not? Can you identify several sources of error in this experiment?

CHALLENGE QUESTIONS

1. In this lab experiment you just finished, you suspended the hanging weight at the center of the 24-inch cord. As a result you probably found that the spring scale readings for F_A and F_B were equal—at least as close as you were able to read the spring scales. Thus the two cords, tied to positions A and B, each carried half the load in holding up the 4-kg mass. Suppose that you had tied the knot in the cord at a point 6 inches from one end and 18 inches from the other, and then suspended the weight at the knot. Then the diagram might have looked like this: For this case, which force (F_A or F_B) do you think would have to be larger? How could you check out your guess?



2. Look at the two diagrams below of forces F_A and F_B holding up a weight F_W.
   a. For which case must the cord be the strongest to hold the weight?
   b. At what angle (between F_A and F_B) would each spring scale read *exactly half* of the hanging weight?



Review

1. ***View and discuss the video, "Force in Mechanical Systems."***
2. ***Review the Objectives and Main Ideas of the print materials in this subunit.***
3. ***Your teacher may give you a test over Subunit 1, "Force in Mechanical Systems."***

Data Sheet

Interval	s (distance)	t (time)	Average v (velocity) (s/t)	change in v	a (acceleration) (change in v/t)
0 , 1				XXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXX
1 , 2					
2 , 3					
3 , 4					
4 , 5					
5 , 6					
6 , 7					
7 , 8					
8 , 9					
9 , 10					
10 , 11					
11 , 12					
12 , 13					
13 , 14					
14 , 15					
			Total		
			Average		

Possible causes of error:

Laboratory: Archimedes' Principle

From: Physics for Career Education Laboratory Manual, by Ewen, Nelson, Schurter and Rao

PURPOSE

The purpose of this lab is to show that the weight of the liquid displaced by a submerged body is equal to the buoyant force which the liquid exerts on that body.

EQUIPMENT

Overflow can
Catch bucket (beaker)
Platform balance
Masses
String

PROCEDURE

Objects which are less dense than water float in water due to the upward force exerted by the water. those objects which are more dense than water seem to lose some of their weight when submerged in water. This is also due to an upward force exerted by the water. We will measure this upward force (buoyant force) and compare it to the weight of the displaced water.

1. Attach the metal block to the platform balance with a light thread.

2. Carefully find the mass of the block and calculate its weight. record this value in the table.

3. Lower the block into the beaker of water so that it is completely below the surface and does not touch the sides of bottom of the beaker.

4. Record the apparent mass and weight of the block while submerged.

5. Find the upward force (buoyant force) exerted on the block by subtracting its weight in water from its weight in air.

6. Find and record the weight of the catch bucket alone.

7. To find the weight of the water displaced by the block, fill the overflow can to the spout. Set the empty catch bucket below the spout. holding the thread, slowly lower the block into the overflow can until it is completely submerged.

8. Find and record the weight of the catch bucket and water.

DATA TABLE

TRIAL	MASS OF BLOCK IN AIR (g)	WEIGHT OF BLOCK IN AIR (N)	APPARENT MASS OF BLOCK IN WATER (g)	APPARENT WEIGHT OF BLOCK IN WATER (N)
1				
2				

TRIAL	APPARENT LOSS IN WEIGHT (BUOYANT FORCE) (N)	WEIGHT OF DISPLACED WATER AND CATCH BUCKET (N)	WEIGHT OF CATCH BUCKET (N)	WEIGHT OF DISPLACED WATER (N)
1				
2				

Communications Curriculum

DESCRIPTION

When you describe someone or something, you give a picture in words to your readers. To make the word picture as vivid and real as possible, you must observe and record specific details that appeal to your readers' senses (sight, hearing, taste, smell, and touch). More than any other type of essay, a descriptive paper needs sharp, colorful details. Here is a sentence in which almost none of the senses is used: "In the window was a fan." In contrast, here is a description rich in sense impressions: "The blades of the rusty window fan clattered and whirled as they blew out a stream of warm, soggy air." Sense impressions here include sight (*rusty window fan, whirled*), hearing (*clattered*), and touch (*warm, soggy air*). The vividness and sharpness provided by the sensory details give us a clear picture of the fan and enable us to share in the writer's experience.

In this section, you will be asked to describe sharply a person, place, or thing for the readers through the use of words rich in sensory details. To help you prepare for the assignment, first read the three essays ahead and then answer the questions that follow.

ESSAYS TO CONSIDER

Family Portrait

My mother, who is seventy years old, recently sent me a photograph of herself that I had never seen before. While cleaning out the attic of her Florida home, she came across a studio portrait she had had taken about a year before she married my father. This picture of my mother as a twenty-year-old girl has fascinated me from the moment I began to study it closely.

The young woman in the picture has a face that resembles my own in many ways. Her face is a bit more oval than mine, but the softly waving brown hair around it is identical. The small, straight nose is the same model I was born with. My mother's mouth is closed, yet there is just the slightest hint of a smile on her full lips. I know that if she had smiled, she would have shown the same wide grin and downcurving "smile lines" that appear in my own snapshots. The most haunting features in the photo, however, are my mother's eyes. They are exact duplicates of my own large, dark brown ones. Her brows are plucked into thin lines, which are like two pencil strokes added to highlight those fine, luminous eyes.

I've also carefully studied the clothing and jewelry in the photograph. My mother is wearing a blouse and skirt that, although the photo was taken fifty years ago, could easily be worn today. The blouse is made of heavy eggshell-colored satin and reflects the light in its folds and hollows. It has a turned-down cowl collar and smocking on the shoulders and below the collar. The smocking (tiny rows of gathered material) looks hand-done. The skirt, which covers my mother's calves, is straight and made of light wool or flannel. My mother is wearing silver drop earrings. They are about two inches long and roughly shield-shaped. On her left wrist is a matching bracelet. My mother can't find this bracelet now, despite the fact that we spent hours searching through the attic for it. On the third finger of her left hand is a ring with a large, square-cut stone.

The story behind the picture is as interesting to me as the young woman it captures. Mom, who was earning twenty-five dollars a week as a file clerk, decided to give her boyfriend (my father) a picture of herself. She spent almost two weeks' salary on the skirt and blouse, which she bought at a fancy department store downtown. She borrowed the earrings and bracelet from her older sister, my aunt Dorothy. The ring she wore was a present from another young man she was dating at the time. Mom spent another chunk of her salary to pay the portrait photographer for the hand-tinted print in old-fashioned tones of brown and tan. Just before giving the picture to my father, she scrawled on the lower left-hand corner, "Sincerely, Beatrice."

When I study this picture, I react in many ways. I think about the trouble that Mom went to in order to impress the young man who was to be my father. I laugh when I look at the ring that was probably worn to make my father jealous. I smile at the serious, formal inscription my mother used in this stage of the budding relationship. Sometimes, I am filled with a mixture of pleasure and sadness when I look at this frozen long-ago moment. It is a moment of beauty, of love, and--in a way--of my own past.

My Fantasy Room

Recently, the comic strip "Peanuts" had a story about Lucy's going to camp for two weeks. At Camp Beanbag, Lucy tells Charlie Brown, there is no flag raising or required activity. All the campers do is lie in a room in beanbag chairs and eat junk food. This idea appealed to me, and I began to think. If I could spend two weeks in just one place, what would that place be like? I began to imagine the room of my dreams.

First of all, my fantasy room would be decorated in a way that would make me feel totally at ease. The walls would be painted a tasteful shade of pale green, the color supposed to be the most soothing. Psychologists have conducted studies proving that color can affect a person's mood. Also, a deep plush carpet in an intense blue would cover the floor from wall to wall--the perfect foundation for padding silently around the room. In the entryway, huge closets with sliding doors would contain my wardrobe of size-eight designer originals. The closets I have now are always messy and crowded, stuffed with old shoes and other kinds of junk. Lastly, on the walls, silver frames would hold my memories: pictures of me with my sports star and musician friends, news clippings reporting on my social life, a poster advertising the movie version of my most recent best-selling novel. Everything would be quiet and tasteful, of course.

I'd have a king-sized bed with a headboard full of buttons that would allow me to turn on lights, start music playing, or run hot water for my Jacuzzi bath without getting up. Tall bookcases with enough shelf space for all the souvenirs from my world travels would line an entire wall. Against the opposite wall would be a chrome and glass desk topped with lined pads and a rainbow of felt-tipped pens. They would await the moment when I became inspired enough to begin writing my next best-seller. And for my purebred Persian cat, there would be a lavender satin pillow.

Finally, my fantasy room would have the latest technological advances. The air-conditioning or heating, depending on the season, would function at a whisper. A telephone, operated by a push button from my bed, would put me in touch with the world. Or, if I were feeling antisocial, I could flick on my quadraphonic stereo system and fill the room with music. I could select a movie from my library of videocassette tapes to play on my giant-screen projection TV. Or I could throw a switch, and the satellite dish on my roof would bring me my choice of television programs from all over the world.

It's probably a good idea that my fantasy room exists only in my mind. If it were a real place, I don't think two weeks would be long enough. I might stay in it forever.

The Diner at Midnight

I've been in lots of diners, and they've always seemed to be warm, busy, friendly, happy places. That's why, on a recent Monday night, I stopped in a diner for a cup of coffee. I was returning home after an all-day car trip and needed something to help me make the last forty-five miles. A diner at midnight, however, was not the place I had expected. It was different--and lonely.

My Toyota pulled to a halt in front of the dreary gray aluminum building that looked like an old railroad car. A half-lit neon sign sputtered the message, "Fresh baked goods daily," on the surface of the rain-slick parking lot. Only a half dozen cars and a battered pickup were scattered around the lot. An empty paper coffee cup made a hollow scraping sound as it rolled in small circles on one cement step close to the diner entrance. I pulled hard at the balky glass door, and it banged shut behind me.

The diner was quiet when I entered. As there was no hostess on duty, only the faint odor of stale grease and the dull hum of an empty refrigerated pastry case greeted me. I looked around for a place to sit. The outside walls were lined with empty booths which squatted back to back in their orange vinyl upholstery. On each speckled beige-and-gold table were the usual accessories. The kitchen hid mysteriously behind two swinging metal doors with round windows. I glanced through these windows but could see only a part of the large, apparently deserted cooking area. Facing the kitchen doors was the counter. I approached the length of Formica and slid onto one of the cracked vinyl seats bolted in soldierlike straight lines in front of it.

The people in the diner seemed as lonely as the place itself. Two men in rumpled work shirts sat at the counter, on stools several feet apart, staring wearily into cups of coffee and smoking cigarettes. Their faces sprouted what looked like daylong stubbles of beard. I figured they were probably shift workers who, for some reason, didn't want to go home. Three stools down from the workers, I spotted a thin young man with a mop of black, curly hair. He was dressed in brown Levi cords with a checked western-style shirt unbuttoned at the neck. He wore a blank expression as he picked at a plate of limp french fries. I wondered if he had just returned from a disappointing date. At the one occupied booth was a middle-aged couple. They hadn't gotten any food yet. He was staring off into space, idly tapping his spoon against the table, while she drew aimless parallel lines on her paper napkin with a bent dinner fork. Neither said a word to the other.

Finally, a tired-looking waitress approached me with her thick order pad. I ordered the coffee, but I wanted to drink it fast and get out of there. My car, and the solitary miles ahead of me, would be lonely. But they wouldn't be as lonely as that diner at midnight.

■ Questions

About Unity

1. Which supporting paragraph in "My Fantasy Room" lacks a topic sentence?

____

2. Which two sentences in the first supporting paragraph of "My Fantasy Room" should be omitted in the interest of paragraph unity?

____

____

3. Which sentence in the second supporting paragraph of "Family Portrait" should be omitted in the interest of paragraph unity?

____

About Support

4. How many examples support the topic sentence, "The people in the diner seemed as lonely as the place itself," in "The Diner at Midnight"?
   a. One
   b. Two
   c. Three
5. Label as *sight, touch, hearing,* or *smell* all the sensory details in the following sentences taken from the three essays. The first one is done for you as an example.

   sight *smell*
   a. "As there was no hostess on duty, only the faint odor of stale grease
   hearing *sight*
   and the dull hum of an empty refrigerated pastry case greeted me."

   b. "He was staring off into space, idly tapping his spoon against the table, while she drew aimless parallel lines on her paper napkin with a bent dinner fork."

   c. "Also, a deep plush carpet in an intense blue would cover the floor from wall to wall—the perfect foundation for padding silently around the room."

   d. "The blouse is made of heavy eggshell-colored satin and reflects the light in its folds and hollows."

6. After which sentence in the second supporting paragraph of "The Diner at Midnight" are more details needed?

____

About Coherence

7. Which method of organization (time order or emphatic order) does the first supporting paragraph of "Family Portrait" use?

    ____

8. Which sentence in this paragraph indicates the method of organization?

    ____

9. Which of the following topic sentences in "The Diner at Midnight" is a linking sentence?
    a. "My Toyota pulled to a halt in front of the dreary gray aluminum building that looked like an old railroad car."
    b. "The diner was quiet when I entered."
    c. "The people in the diner seemed as lonely as the place itself."
10. In the first supporting paragraph of "My Fantasy Room," what are the major transition words?

    a. ____________ b. ____________ c. ____________

WRITING THE ESSAY

■ Writing Assignment 1

~~Write an essay about a particular place that you can observe carefully or that you already know well. The place might be one of the following or some other place:~~

~~Pet shop~~
~~Exam room~~
~~Laundromat~~
~~Bar or nightclub~~
~~Video arcade~~
~~Corner store~~
~~Library study area~~
~~Basement or garage~~
~~Hotel or motel lobby~~
~~Your bedroom or the bedroom of someone you know~~
~~Waiting room at a train station or bus terminal~~
~~Winning or losing locker room after an important game~~
~~Antique shop or other small shop~~

Using Commas in a Series

Example

1. Marcella had toast, eggs, bacon, orange juice, and pizza for breakfast.
2. Geraldo is a wonderful husband, a loving father, a good provider, and an all around good person.

You Try It

1. Roses lilacs peonies lillies-of-the-valley and irises are my favorite flowers.
2. Some of things I have to do today are mow the lawn paint the porch go to the gorcery store and pick up the kids from swimming lessons.
3. Chicago St. Louis New York and Detroit are some of the cities I have visited.
4. Please come in shut the door sit down and make yourself comfortable.
5. Harold has had jobs as a bus boy truck driver fork lift operator assembly line worker and landscape artist.
6. The names of the members of my family are Robert Teena Templeton Rowena James Marcie and Geena.

Using Commas With Dates And Addresses

Examples:

Constantine was born on Tuesday, November 18, 1975.

The meeting is set for Monday, June 21, 1993, so try your best to attend.

Send this package to Ms. Abagail Adams, 2156 Ford Street, Baltimore, Maryland 61290, immediately.

My new address is 432 Harris Avenue, Rockford, Illinois 40880.

You Try It

1. My aunt lives at 4087 Montrose Boulevard Memphis Tennessee 48723 but I've never visited her.
2. I will be attending school from Monday June 14 1993 until Friday July 9 1993.
3. Send this letter to Mr. Charles Smith Beloit Corporation 614 LaSalle Street Beloit Wisconsin 53511 immediately.
4. My birthday is next Wednesday June 23 1993 and I am having a big party.
5. Amy said she was arriving on Tuesday July 16 but her visit has now been changed to Wednesday July 24 1993.

You are an aircraft mechanic. An aircraft inspector has just inspected a Beechcraft Baron and found the discrepancies (maintenance needed) listed on the sheet. Use the pages from the maintenance manual that I have provided for you to determine what corrective action must be taken for each item. Answer the questions about each discrepancy.

Windshield Discrepancy

1. What corrective action should you take to clear the windshield?

2. What should you do first?

3. What kind of cloth is used? Why should you use a particular kind of cloth?

4. How do you remove oil and grease from the windshield?

5. How do you get rid of a static charge?

6. How do you clean a windshield with windshield wipers?

Mushy brakes discrepancy

1. What corrective action will you need to take?

2. How can you tell when to add fluid?

3. What kind of hydraulic fluid will you use?

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DISCREPANCY	CORRECTIVE ACTION	
Windshield dirty and bug covered.		MECHANIC
		DATE
2/9/93 MTT		INSTRUCTOR

DISCREPANCY	CORRECTIVE ACTION	
Brake response was mushy on landing rollout		MECHANIC
		DATE
2/9/93 MTT		INSTRUCTOR

DISCREPANCY	CORRECTIVE ACTION	
Landing gear uplock roller lubrication due. Last accomplished 2214.6.		MECHANIC
		DATE
2/9/93 MTT		INSTRUCTOR

DISCREPANCY	CORRECTIVE ACTION	
AD 89-05-02 due Last accomplished 2211.4		MECHANIC
		DATE
2/9/93 MTT		INSTRUCTOR

DISCREPANCY	CORRECTIVE ACTION	
		MECHANIC
		DATE
		INSTRUCTOR

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of a neutral soap and water solution. If necessary, however, the oil may be removed by wiping the boot surface lightly with a rag moistened with toluol or uncontaminated unleaded aviation gasoline. When gasoline is used, the surface should be wiped dry immediately without allowing the gasoline to penetrate into the rubber. Also care should be exercised to avoid scrubbing the surface of the boot as this will tend to remove the thin coating of conductive cement.

NOTE

> Since deicer boots are made of soft, flexible stock, care must be exercised against dragging gasoline hoses over them or resting ladders or platforms against the boot's surface.

PLASTIC WINDOWS

Ordinary cleaning of the plastic windows in the pilot's compartment will cause severe damage to the surfaces and will result in limited vision or costly replacements. To prevent scratching, or distortion of the plastic windows, special care must be taken when cleaning them. Flush the surface with clean water, using the bare hand to dislodge any dirt or abrasives. This will prevent the possibility of scratching the surface during the washing procedure. Wash thoroughly with a mild soap solution, taking care that the water is free from all possible abrasives. A soft cloth, sponge, or chamois may be used to apply the soap solution. Light films of oil or grease may be removed with trisodium phosphate completely dissolved in water. Stubborn oil or grease on the surface may be removed by rubbing lightly with a clean cloth dampened with hexane, aliphatic, naphtha, or methanol. Flush with clean water and then dry the surface with a clean damp chamois. After the surface is dry, continuous rubbing should be avoided as it is likely to cause scratches, also it builds up a static charge which attracts dust particles to the surface. If the surface should become charged, patting or gently blotting with a clean damp chamois will remove the dust and the charge.

When the airplane is equipped with windshield wipers use only Curtiss-Wright CW-100 cleaner and dust repellant to clean the windshield. Cleaner and repellant may be obtained from Curtiss-Wright, Marquette Division, Cleveland, Ohio. For additional information concerning windshield cleaning, refer to handbook A2-01335 included in the loose tool and equipment bag.

CAUTION

> Do not use gasoline, benzene, acetone, carbon tetrachloride, fire extinguisher fluid, deicing fluid, lacquer thinners, dry cleaning fluid, window sprays or kitchen scouring compounds on plastics as they have a tendency to soften and craze or scratch the surface.

FINAL WAX APPLICATION

A thorough waxing protects painted and unpainted metal surfaces by preventing salt air, smoke, moisture and exhaust gas attacks; it retards adherence of sticky airborne dust and minimizes corrosion. The frequency of rewaxing is dependent upon frequency with which regular maintenance cleaning is performed. Apply wax with a soft damp cloth. Rub on surface with a light circular motion, covering an area of approximately two square feet at a time. Polish with a clean dry cloth.

CAUTION

> At time of delivery, painted surfaces should not be polished or waxed until the finish has cured for at least 90 days. No hard rubbing, abrasive cleaners or wax seals detrimental to the proper curing of the finish should be used.

INTERIOR CLEANING

Frequently the seats, rug, upholstery panels and head lining should be vacuum-cleaned to remove as much surface dust as possible.

Experience has shown that commercial foam-type cleaners or "shampoos" can be used to condition the surface of rugs, carpets and upholstered materials. The upholstery is first vacuum-cleaned, stains removed, then a solution of the cleaner is prepared by mixing a small amount in a bucket of water, and beating the mixture until a heavy foam is formed. Apply the foam uniformly over the surface to be cleaned with a brush, then remove the suds with a vacuum cleaner, or by wiping off with a brush or cloth. Since there is very little moisture in this foam, wetting of the fabric or retention of moisture in the warp does not occur. Unlacquered metal fittings and furnishings within the airplane can be cleaned with most commercial metal polishes. Use a soft, clean rag for application; then polish to a brilliant gloss with a dry cloth. Protect the finish with a good grade of wax.

LEATHER UPHOLSTERY

Leather upholstery should be kept waxed for maximum protection. For cleaning, a nonabrasive, chemically neutral, nonreactive, emulsion type cleaner of cream-like consistency is recommended. Dilute the cleaner with water, and apply it over the dirty surface with a sponge or soft cloth (use a gentle wiping motion, do not scrub). The solution should not be allowed to stand, but should be wiped off before drying.

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CONSUMABLE MATERIALS CHART (Cont'd)

ITEM	MATERIAL	SPECIFICATIONS	VENDOR PRODUCTS
			Phillips 66 Aviation Engine Oil, Grade 1065, Phillips Petroleum Co., Bartlesville, Oklahoma Or any approved aircraft engine oil (graded at 1100 or 1065)
7.	Lubricating Oil (Gear)	MIL-L-2105 Grade 75 or 101-380016-1	Mobilube SHC, Mobil Oil Corp., Shoreham Building, Washington, D.C.
8.	Lubricating Grease (General Purpose) (Superseded by MIL-G-81322)	MIL-G-7711	
9.	Lubricating Grease (High Temperature)	**MIL-G-81322	Mobilgrease 28, Mobil Oil Corp., Shoreham Building, Washington D.C. Aeroshell No. 22, Shell Oil Co., 50W 50th Street, New York, N.Y.
10.	Lubricating Grease (Gear)	Mobil Compound G.G. or Mobil 636	Mobil Oil Corp., Shoreham Building, Washington, D.C.
11.	Lubricating Grease (Aircraft and Instruments, Low and High Temperature)	**MIL-G-23827	Supermil Grease No. A72832, American Oil Co., 910 South Michigan Ave., Chicago, Ill. 60680 Royco 27A, Royal Lubricants Co., River Road, Hanover, N.J. Shell 6249 Grease, Shell Oil Co., 50 West 50th St., P.O. Box 95, New York, N.Y. 07936
12.	Lubricant Molybdenum Disulfide Powder	MIL-M-7866	Molykote Z, Wilco Co., Wichita, Kansas Molykote Z, Standard Oil of Kentucky Molykote Z, Hafkel Seals, Glendale, California

Health Occupations

Lesson 8: Following Oral Directions

Introduction

Directions at work are often presented orally. When you listen for a supervisor or co-worker to begin giving directions, you will not always know how long or complicated the directions will be. It is also difficult to know quickly if the directions are complete and whether they will be accompanied by appropriate diagrams and illustrations. If the task is new or unfamiliar, the directions may seem more difficult to understand than they really are. Other factors such as your attitude or distracting noises can also affect how well you listen. Following oral directions well takes effort and practice. To follow directions effectively, you must begin with a positive attitude and develop a habit of active listening in order to understand and remember what to do.

In the three parts of this lesson you will

- read guidelines for following oral directions (**Introduction**).
- practice listening to and following oral directions in the workplace (**Application**).
- get additional practice following oral directions (**Follow-up**).

When you are improving your ability to follow oral directions, it is helpful to have a set of guidelines. Remember these guidelines when you must follow oral directions.

Guidelines for Following Oral Directions

Before the specific directions are given, **Plan**. Get ready to listen.

- Stop what you are doing. Stop talking, look at the speaker, and think about your purpose for listening.
- Identify the task.
- Ask if you should be prepared to take notes.

During the direction giving, listen actively.

- Listen attentively, that is, listen to know what to do and how to do it. Make sure you hear the speaker clearly.
- Look at the speaker. Maintain eye contact.

- Listen for safety precautions and equipment needs.
- Listen for the order or sequence of steps.

After part or all of the directions are given, **Check** and **Clarify**.

- **If** the steps are unclear, ask questions. (Silence may indicate to the speaker that you do not understand what to do.)
- **If** unfamiliar terms or phrases are used, listen to the sentences in which they occur and ask for examples.
- Repeat or summarize what you are to do.
- Review the steps in your own mind and review any notes you may have taken.
- Ask detailed questions of the direction giver or consult a manual, handbook, or an expert.
- **If** the directions are still not clear, get more information. ■

Application

Active listening is important on the job. Practice active listening skills as you play the part of an employee who is given directions for working at Community General Hospital.

As you are listening, **check** your understanding. Do you know what to do and how to do it? If you are not sure of what to do, **clarify**, ask questions or get more information. For health care workers, checking and clarifying often means looking at a schedule, a patient care plan, or at notes taken during report. For the following activity, you will need the help of another person who will play the role of your employer and give (read) the directions to you. **Plan** what to do and how to do it.

Working at Community General

Imagine you are a new employee at Community General Hospital. Your instructions for the day are given during the report at the beginning of your shift. Your workday activity usually begins when you help deliver breakfast trays to the patients. Listen to your instructions. Take notes. Use the Community General Hospital "Forth Floor Patient List," "Fourth Floor Diet Sheet", and the "Medical/Surgical Floor Plan" (or copies of these forms) to help you.

Write a number in the box next to each name on the patient list below (or a copy of it) to show the order in which the trays were delivered. For example, write **1** next to the patient who received the first tray; write **2** next to the name of the patient who received the second tray, and so on.

Community General Hospital
Fourth Floor Patient List

Sequence	Patient Name	ID#	Room
[ ]	Mrs. Ann Anderson	#01	119
[ ]	Miss Angela Corsa	#02	112
[ ]	Mrs. Jan Evans	#03	120
[ ]	Mrs. Helen Gant	#04	110
[ ]	Mrs. Lynn Hatter	#05	115
[ ]	Mrs. Mary Moss	#06	124
[ ]	Mr. Tim Mitchell	#07	121
[ ]	Miss Ruth Norris	#08	123
[ ]	Mr. Richard Overs	#09	111
[ ]	Mr. Juan Rames	#10	116

Community General Hospital
Fourth Floor Diet Sheet

ID#04 Room 110
Tea, clear broth

ID#02 Room, 112
Prune juice, scrambled eggs,milk

ID#10 Room 116
O. juice, oatmeal, muffin, coffee

ID#01 Room 119
O. juice, soft egg, toast, coffee

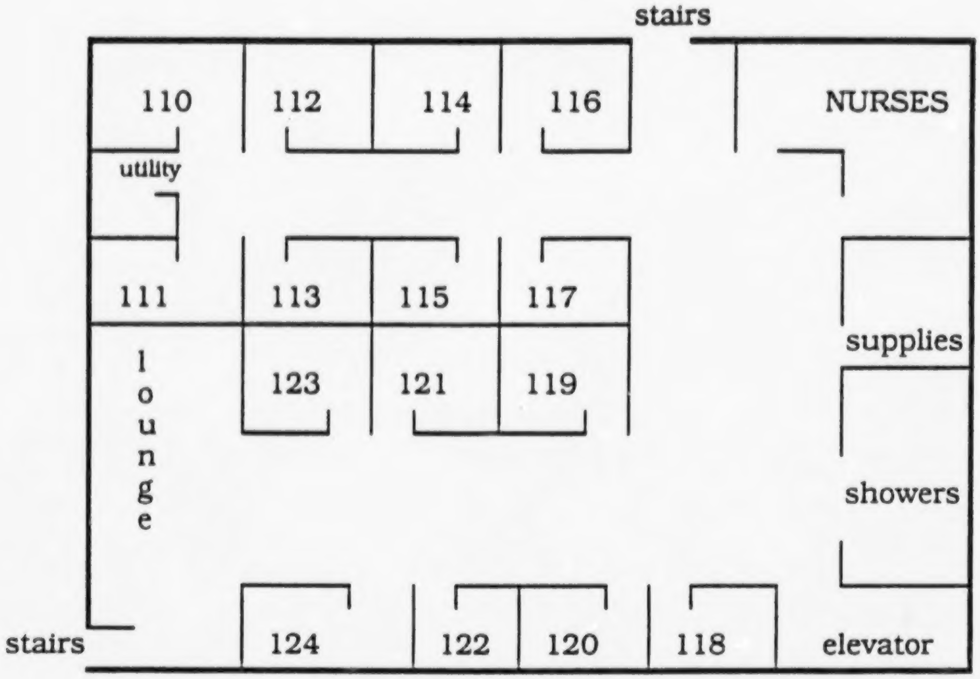
ID#03 Room 120
O. juice, cold cereal, toast, coffee

ID#07 Room 121
Tea, clear broth

ID#08 Room 123
Apple juice, soft egg, toast, tea

ID#06 Room 124
Apple juice, Oatmeal, English muffin, tea

Community General Hospital
Medical/Surgical Floor Plan


stairs
110
112
114
116
NURSES
utility
111
113
115
117
supplies
lounge
123
121
119
showers
stairs
124
122
120
118
elevator

(This section is for the person reading the directions.) Read these instructions for delivering morning breakfast trays at the hospital to yourself. Then read the instructions aloud to your partner as though you were a supervisor giving instructions to an employee.

> **You already have a patient list and the list of morning diet sheets. Pick up the breakfast trays at the nurses' station as soon as they arrive. That should be about 7:30. Deliver them to the appropriate patients. Make sure each patient receives the correct tray. Start with the trays for those patients farthest away from the nurses' station. (By the way, Mrs. Hatter has surgery scheduled for 10:00 A.M. and Mr. Overs will have lab tests at 8:30 A.M. They probably won't be happy since they can't have anything to eat or drink this morning.)**

Follow-up

The following activity gives you another opportunity to practice active listening skills. In order to complete the activity, you will need the help of another person who will give (read) directions to you for seating patients in a dental office. The other person will play the role of your employer (a dentist).

On your own paper draw four columns. Label the first column "Station," the second column "Patient," the third "Procedure," and the fourth "Notes."

Imagine you are a dental assistant working in a busy office. Listen to the directions the dentist gives for seating patients.

Plan what to do and how to do it. For example, know who the patients are and what will be done during the appointment. Make a brief list to keep with you as a reminder. **Check** your understanding. You should know what to do. If the directions are unclear or incomplete, **clarify** by asking questions or obtaining more information from the appointment schedule below (Figure 32).

Show where you placed each patient by writing his or her name in the correct column along with any special reminders or notes.

Hazel Nopane, DDS

8:00	Ricky Gumbo (child)	braces fitting
8:15	Alice Aches (child)	6 month checkup
8:30	Barbara Bahan	bicuspid extraction
8:45	Bob Krawalko	molar filling
9:00	Andy Zukach	braces fitting
9:15	Darryl Longo	bicuspid filling
9:30	Jim Shea	extraction
10:00	Cindy Laughin	root canal
10:15	Anna Lacek	denture fitting
10:30	Eva Pelsky (child)	extraction
10:45	Jack Pelsky (child)	braces fitting
11:00	Ann Warren	1 year checkup
11:30	Noah Stein (child)	braces fitting

Figure 32: Appointment Schedule

(This section is for the person giving the directions.) Read these instructions for seating patients at stations in a dental clinic to yourself. Then read the instructions aloud to your partner as though you were the dentist giving instructions to a dental assistant.

> **We're going to have two patients in this morning for checkups and I want them seated only at station #4. Station #3 is for the two extraction clients at 9:30 and 10:30. Station #2 will be used for the clients who are to be fitted with braces or dentures. Remember to stay with the younger clients until the hygienist or I come in. We don't want the children left alone. Don't forget to put the patients' impressions on the counter if they are being fitted with braces. Also be sure to give those patients extra wax to help protect their gums. Make sure to make follow-up appointments with those patients who will need further care or checkups.**

◆

Health Occupations
Lesson 9: Following Written Directions

Introduction

You are most likely to need written directions on the job when you must act carefully and not make any mistakes. Written directions will help you follow several steps to finish a task. They are also helpful when safety is important and when you are operating equipment for the first time. You will not always be able to spend a long time trying to figure out what you are supposed to do. Reading on the job is reading for a specific purpose—to get the job done.

In the three parts of this lesson you will

- read guidelines for following written directions (**Introduction**).
- practice reading written directions in the workplace (**Application**).
- get additional practice following written directions (**Follow-up**).

While you are improving your ability to follow written directions, it will be helpful to have some guidelines or criteria for judging the effectiveness of these directions.

Guidelines for Following Written Directions

Plan

- Skim to determine the type of information needed. Skim the directions to determine organization, complexity, and the location of specific information.
- Read for details (make notes, underline important points).

Check understanding

- Summarize the directions in your own words.

Clarify, if necessary

- Reread the critical steps.
- Act step-by-step, referring to the directions as needed.

Application

Important instructions or procedures are often stated in writing. If written directions are not read and followed carefully, it could result in a serious problem for you and possibly your employer. In the following activity you will practice following a patient care plan in a geriatric nursing home.

Following a Patient Care Plan

As a geriatric nurse working in a nursing home, you are responsible for reading the patient care plan and completing the assigned nursing care. Today you are assigned to Mr. Thomas for the day shift from 6:45 a.m. to 3:15 p.m. Read the patient care plan below. Then, **plan** what to do and how to do it. **Check** your understanding, and **clarify**, if necessary, before you complete the schedule of care for Mr. Thomas. List the activities on the form below (or a copy of it), in the order you will perform them.

Mountain View Nursing Home

Patient Care Plan

Patient: Mr. James Thomas Diagnosis: Stroke Room: 111

Diet: soft diet and force fluids; meals are to be taken in the dining room.

Nursing care:

Daily tub bath or shower with minimal assistance
Ambulate with assistance (qid)
Occupational therapy each morning at 10 a.m., Monday through Friday

---

Schedule of care for: James Thomas

Activity:	Time:

Special Cautions:

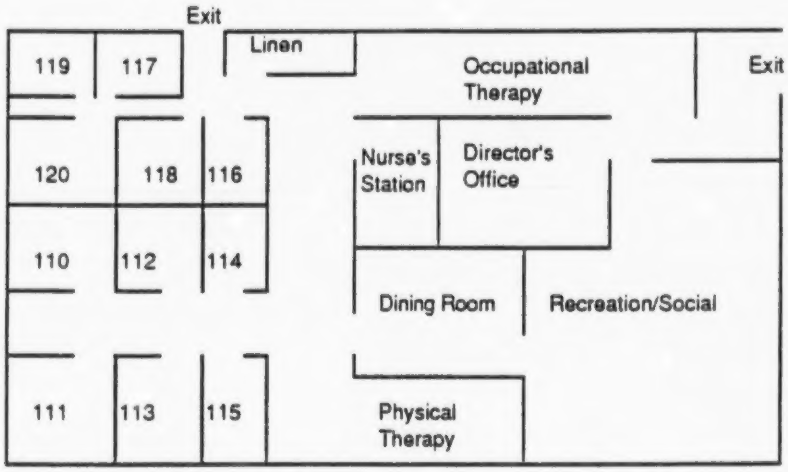
Follow-up

The following activity gives you the opportunity to practice following written directions on your own. In this activity you will help an older patient walk to locations within a nursing home.

You must help Mr. Thomas walk from his room to the dining room and to the occupational therapy area. Study the floor plan below. Mark the route on the floor plan (or a copy of it) showing how you would walk with Mr. Thomas to those areas.

Mountain View Nursing Home

Floor Plan


Exit
Linen
119
117
Occupational Therapy
Exit
120
118
116
Nurse's Station
Director's Office
110
112
114
Dining Room
Recreation/Social
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Physical Therapy

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Health Occupations

Lesson 10: Creating Written Directions

Introduction

Good written directions tell how to do something step-by-step and are written with the user in mind. They include special warnings and tell what tools and equipment are needed to do the job. Good directions give exact information and enough information.

In the three parts of this lesson you will

- read guidelines for creating written directions (**Introduction**).
- practice creating written directions in the workplace (**Application**).
- get additional practice creating written directions (**Follow-up**).

When creating written directions, it is useful to have a set of guidelines. Use the following guidelines each time you create directions.

Guidelines for Creating Written Directions

Before writing directions

Plan

- Know the subject and, if necessary, consult appropriate manuals, policy handbooks, or experts.
- Visualize the task.
- Think about your purpose for writing the directions.
- Take notes or make a list of the steps to be followed.
- Consider the people who will use the directions and the words or terms that will help them understand the directions.
- Think about the location or environment in which the directions will be used. Purpose, audience, and context all affect the way the directions are written.
- Recall any health or safety concerns and list all materials or equipment that will be needed.

While writing

- Briefly state the task to be performed, state the situation in which the task is to be completed, state its importance, and list any materials or equipment that will be needed.
- Present the information in steps and in sufficient detail.
- Highlight important information.

Check

- Make sure the directions match your purpose and the user's needs. Check for content, form, spelling, grammar, and punctuation.
- Let one or more persons read the directions. Ask whether the directions are clear, the language is precise, or if any information is missing.

After finishing the draft of the directions

Clarify

- Make any necessary changes to the directions before giving them to users.

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Application

In many work situations, you must follow specific procedures that, if omitted or not performed properly, will lead to difficulty. Important procedures need to be put in writing for use or future reference. In the following activity you will practice developing a set of directions for assisting a blind patient.

Assisting a Blind Patient with Meals

We often take our senses, such as hearing and sight, for granted. When a person has lost his or her sight, even a simple activity such as eating can be difficult. Health-care workers know that most people who are blind want to remain as independent as possible. These individuals can be given directions for helping themselves. If the directions are inadequate or confusing, the individual may not be able to eat comfortably. He or she could even be harmed by hot liquids or other hazards.

Imagine you are a health care worker who has been assigned to help care for Mrs. Wong in her home. Because Mrs. Wong is now blind, Mr. Wong has asked you to write out for him the directions for serving a meal to her. She must know where to find the food on her plate so that she can feed herself.

Plan the directions for Mr. Wong. Make a list of what Mr. Wong needs to know and what he should do. For example, he should think about the plate as a clock with reference points for telling her where the food is located. He must warn Mrs. Wong about the location of hot liquids. Write a set of instructions for Mr. Wong and other family members to follow in helping Mrs. Wong eat a breakfast of scrambled eggs, toast, a slice of cantaloupe, and a cup of hot tea **OR** another meal involving a plate of food. Make the directions specific, not general. When planning the directions, think of the plate as a clock with the middle of the top of the plate as 12 o'clock and the middle of the bottom as 6 o'clock. (See Figure 33.)

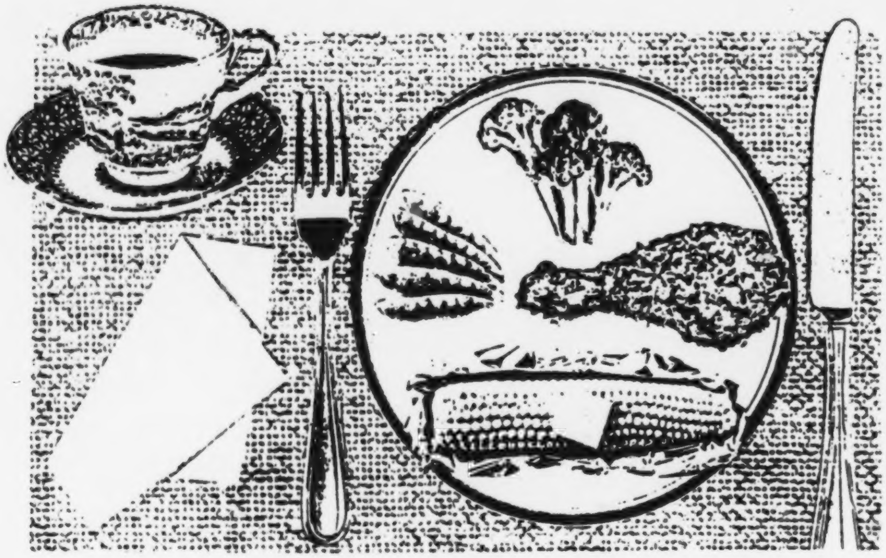

Figure 33: Meal for Mrs. Wong

Check the directions. Test to see if your directions work by having an imagined meal with another student. Take turns being blindfolded and acting the role of "patient" and assuming the role of home health nurse. In this role, read the directions you have written and have the "patient" follow them. Can your patient find his or her eating utensils and food? Remember, you are responsible for your client's safety, so protect him or her from any possible harm such as hot liquids or sharp objects.

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Clarify your directions, if necessary, based on the test. You might want to include a small diagram to illustrate the directions.

■

Follow-up

The following activity gives you the opportunity to practice creating written directions on your own. In the activity you will develop a set of directions to help a patient climb stairs using crutches.

The physical therapist must teach patients how to walk on crutches. If the instructions are not followed correctly, the patient might be injured. For example, the patient could receive nerve damage from placing the crutches under his or her arms incorrectly, or he or she could fall trying to go up or down stairs. Imagine that you are a physical therapist and have been asked by a patient's family to write a set of directions for climbing stairs using crutches. The client is wearing a walking cast on his right leg.

Use the following illustration (Figure 34) to help plan your directions. The directions should be based on the position of the feet. **Plan** by making a list of what to do and how to do it. You will want to pay special attention to the order of the steps in your directions. After you have written the directions, **check** them and **clarify** or revise if necessary.

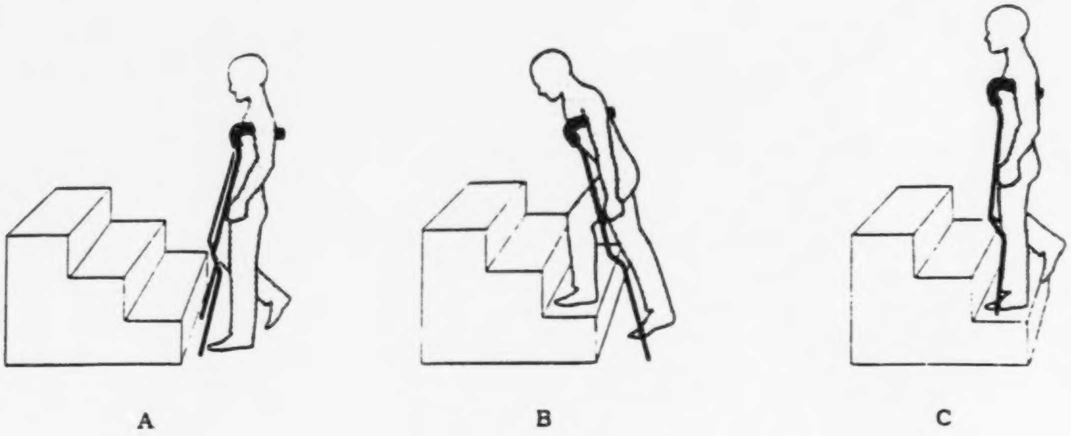

Figure 34: Using Crutches

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Application

Health care workers share objective and subjective information about patients with their co-workers. Objective reporting involves sharing what you see, hear, smell, and feel by touching. Subjective reporting involves sharing information that is an opinion or that cannot be proven like objective information. If a patient is crying, you may think he or she is upset, a subjective judgment on your part. On the other hand, objective information is that you observed tears in the patient's eyes. If a patient says he or she has a headache, you report it: patient complains of a headache. You cannot see, feel, hear, or touch the headache. You may think the patient has an infected finger but you report: right index finger is red, swollen, and hot to the touch. Objective reporting is very important.

An incident report is used to share any unusual or unexpected event. Like other forms of charting, this written communication provides factual (objective) information and is a legal document.

Suppose you are the medication nurse in a hospital on the 3-11 P.M. shift. It is 9:15 P.M. and you are passing out the bedtime medications. You walk into room 403 and see Mr. Ronald Schart, age 76, lying on the floor beside his bed; his bedrails are still in the up position.

Nurse: **"Mr. Schart, are you hurt?"**

Patient: **"I can't seem to move my right leg. I wanted to go to the bathroom, but I couldn't get those bars out of my way and fell."**

You examine Mr. Schart. His right leg is under his body and he can't move it. He says he doesn't hurt anywhere else as you check his head, arms, and the rest of his body. You push the call bell for assistance. When the call is answered you explain what has happened and you ask that the charge nurse notify the doctor and call an orderly to help move Mr. Schart.

Nurse: **Mr. Schart, do you know where you are now?**

Patient: **"Sure, I'm laying on the floor with a broken leg."**

Nurse: **"What was wrong with you that made you come to the hospital?"**

Patient: **"I have a kidney infection and the doctor wanted to do some kidney tests and check everything. He said it was important because I already have high blood pressure, too."**

You check Mr. Schart's blood pressure, pulse, and respiration: B/P 154/96, P 64, R 18. With assistance, you immobilize Mr. Schart's right hip and leg and lift him into bed. His doctor, Dr. Williams, was called and has ordered X rays and vital signs every 30 minutes times 2. Dr. Williams will see Mr. Schart again after the X rays are read.

Fill out the following incident report (or a copy of it).

General Hospital Incident Report

Name of person completing report: ______________________________

Title: ______________________________

Location of incident: ______________________________

Time: __________ **Date:** __________

Person involved: Patient: ____________________ **Room #** ________ **OR**

Employee: ____________________ **OR** **Visitor:** ____________________

Was any equipment involved? Yes ______ **No** ______ **If yes, describe:**

Describe the incident: (Who, what, when, where, why, and how)

If the incident involved a patient, describe the patient's mental condition:

What was patient's diagnosis upon admission? ____________________

Where side rails in use? Yes ______ **No** ______

Was a physician notified? Yes ______ **No** ______

Name of physician: ____________________ **Time notified:** __________

Was person seen by a physician? Yes _____ **Time** _____ **No** _____

Describe treatments or actions taken after the incident:

Name, telephone, and addresses of witnesses:

____

____

The supervisor must complete and sign the reverse side of this form.

Follow-up

At 10:30 A.M. your patient, Mrs. Jane Springer, is brought back to her room (#307) from X ray. You will be helping the transportation orderly get her off the carrier and onto her bed. As you try to put the side rail of the carrier down, it seems to be stuck. Suddenly it moves and your finger is caught between the rail and the metal release catch. This results in a dime-sized piece of skin being torn on the end of your right index finger.

The torn place is bleeding, and your nail is hurting from being mashed. You rinse off the finger and it stops bleeding. Then you bandage your finger and put on a rubber glove so you can finish helping Mrs. Springer back to bed. You then clean and disinfect the side rail and release catch.

Later, you report the accident to your charge nurse who tells you to go see the emergency room doctor and fill out an incident report. In the emergency room, Dr. Rutherford examines your finger. The finger is cleaned with an antiseptic and re-bandaged. You receive a tetanus shot.

Fill out the incident report on page 112 (or a copy of it).

General Hospital Incident Report

Name of person completing report: ______________________________

Title: ______________________________

Location of incident: ______________________________

Time: __________ **Date:** __________

Person involved: Patient: ____________________ **Room #** ________ **OR**

Employee: ________________ **OR** **Visitor:** ________________

Was any equipment involved? Yes ______ **No** ______ **If yes, describe:**

Describe the incident: (Who, what, when, where, why, and how)

If the incident involved a patient, describe the patient's mental condition:

What was patient's diagnosis upon admission? ____________________

Where side rails in use? Yes ______ **No** ______

Was a physician notified? Yes ______ **No** ______

Name of physician: ____________________ **Time notified:** __________

Was person seen by a physician? Yes ______ **Time** ______ **No** ______

Describe treatments or actions taken after the incident:

Name, telephone, and addresses of witnesses:

____

____

The supervisor must complete and sign the reverse side of this form.

When you speak or write

- use words and terms that are precise and appropriate to your occupational area with co-workers who work in that area.
- use simple, nontechnical language to communicate with co-workers outside of your occupational field.

Application

Effective communication in health occupations requires knowledge of medical terms and abbreviations. While some terms are specific to one particular occupation, many terms are used in a variety of health occupations. Educational programs in medicine, dentistry, nursing, and allied health offer medical terminology as a basic course.

It is important for health occupations workers to understand and use medical terminology as they deal with other health personnel. In the two activities that follow, refer to the glossary on page 115 that lists a few of the terms and abbreviations from the medical field.

Activity A

On a separate sheet of paper, write the following information from a patient's chart in common language.

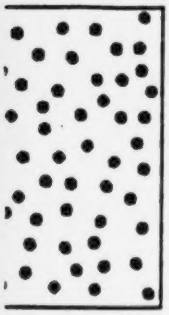
> PE: Mrs. Jean Parson, a 74 yo WF was admitted to ICCU c/o chest pain. B/P 160/96, P 96, R 24. Diaphoresis noted. EKG revealed frequent PVC's, frequent PAC's with sinus arrhythmia. PH: CVA in 1988 with Lf side paralysis c speech impairment. Regained partial use of Lf hand and arm c PT. Amb c cane.

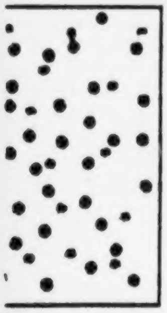
Activity B

On a separate sheet of paper, write the following information about a patient using medical terms and abbreviations.

> Physical exam: Wilma Holmes, a 17-year-old black female car-wreck victim, admitted to emergency room complaining of pain in right arm with loss of movement. Laceration on left forehead. Blood pressure 124/80, pulse 88, respiration 20. X ray of right arm reveals a compound fracture of the humerus. Past history: usual childhood diseases; no known allergies.

Abbreviation or term	Definition
Amb	ambulatory
ambulate	to walk
appendectomy	removal of the appendix
appendicitis	inflammation of the appendix
BF	black female
Bid	twice a day
B/P	blood pressure
c	with
cmpd Fx	compound fracture
c/o	complaining of
CVA	cerebrovascular accident, medical term for a stroke
diaphoresis	profuse or extreme sweating
EKG (ECG)	electrocardiogram, the record of the electrical activity of the heart; wires are placed on the chest wall and a machine records the electrical activity on a graph
ER	emergency room
humerus	bone of the arm which extends from the shoulder joint to the elbow
ICCU	intensive coronary care unit
lf	left
NKA	no known allergies
P	pulse
PAC	premature atrial contractions, upper chambers of the heart force the blood out prematurely
PE	physical exam
PH	personal history
PT	physical therapy
PVC	premature ventricular contractions, lower chambers of the heart force the blood out prematurely
R	respirations
ROM	range of motion of joints exercises
Rt	right
sinus arrhythmia	a lack of rhythmical beating of the heart; irregular heart beat
STAT	immediately
UCHD	usual childhood diseases
WF	white female
yo	year old





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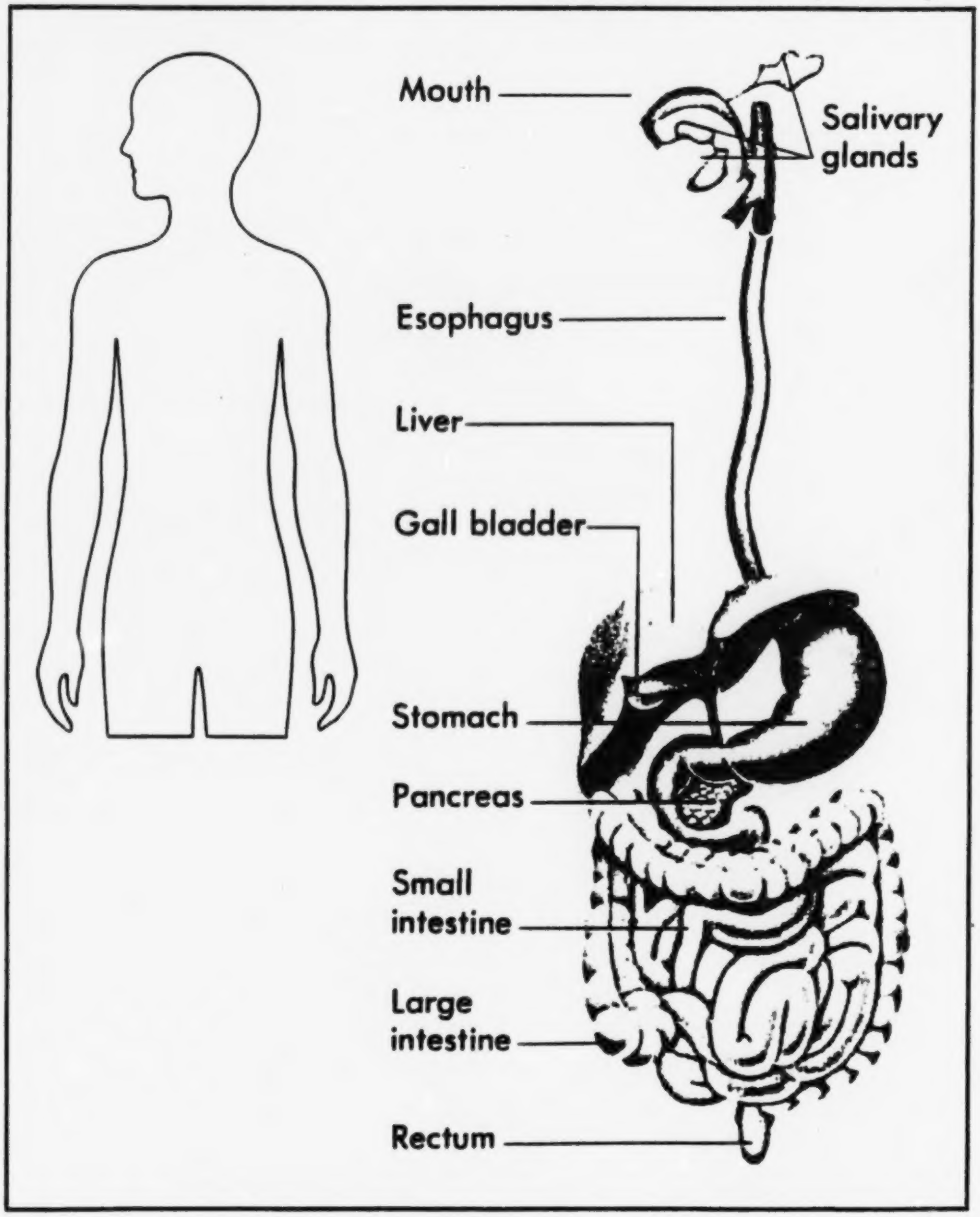
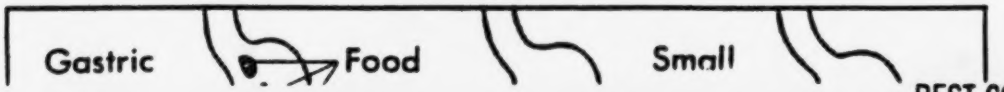
Digestion

Digestion is the process that breaks food down into simple substances the body can use. The digestive system includes all the organs and tissues involved in this process.

Parts of the digestive system

WORLD BOOK illustrations by Colin Bidgood


Mouth
Salivary glands
Esophagus
Liver
Gall bladder
Stomach
Pancreas
Small intestine
Large intestine
Rectum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Summer Institute
English Curriculum

Week 1 - June 14 - June 17 (Food Science Emphasis)

Monday, June 14

8-8:45 a.m. - Orientation and Determining course evaluation with students

10:30 Introductions, expectations of class

Introduce business letter writing format

Objective: Students will learn/review correct business letter format including correct spacing, punctuation, abbreviations, heading, inside address, salutations, complimentary close.

Tuesday, June 15

Business letter applications
Objective: Students will write a business letter requesting information about Food Science careers, using correct business letter format, correct punctuation, sentence structure, spelling. Students will compose the letter in class, hand in a draft, make corrections and make a final copy for mailing later in the course.

Wednesday, June 16

Objective: Students will write a description of molds as seen under a microscope in science lab, using adjectives for vividness, clarity, specificity, creativity. Drawings to accompany descriptions will be encouraged.

Assignment: Prepare students for Thursday's assignment - Lab Report

Thursday, June 17

Objective: Students will write a lab report based on science lab, enzymatic browning. Lab report will include introduction, procedures, results, conclusions. Emphasis will be on lab report format, correct spelling and grammar, writing complete sentences.

Week 2 - June 21-June [illegible] (Aviation Emphasis)

Monday, June 21

Film on Aviation Careers - "Put Wings on Your Career" - Tour of Facility

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Tuesday, June 22

Objective: Reading and Interpreting aviation maintenance manuals, analyzing information, critical thinking skills. Students will be given specifications which aircraft must meet for safety. Students will read instruction manuals, decide if and what maintenance work needs to be done on aircraft.

Wednesday, June 23

Objectives: Problem solving skills, interacting in small groups, listening for others' opinions, stating one's own opinion clearly and concisely, using persuasion.

Students will divide into four groups of five. Based on a math problem from math class earlier (involving take-off distances, head wind, weather conditions, etc.) students must decide whether to take off under adverse weather conditions. Situation: CEO of important national company which does a lot of business with your charter aircraft company, will be late for his very important meeting if you, the pilot, decide not to take off. Groups will weigh pros and cons of both sides and make a decision; representatives from each group will explain specifically that group's decision and why that decision was made. If time, role play, CEO and pilot.

For Thursday - Think about a career area you would like to explore.

Thursday, June 24

Objective: Career Exploration, library research, note taking skills, finding information.
Students will go to library where they will be given a short overview of where to find career information. Individually, or in pairs (if interests coincide), students will research as much information as possible about any career area of their choice. Specific questions they will want to find answers for:

What kinds of courses will I need to take in high school to be well prepared?
How much education after high school will I need?
Which schools offer this education?
Cost of education?
What will I do on the job?
Starting pay and benefits?
Availability of jobs?
Other occupations which might branch off of this career?

Week 3 - June 28-July 2 (Health Occupations Emphasis)

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Monday, June 28

Objective: Written report of career exploration, writing skills, organizational skills, grammar, punctuation, sentence structure, spelling skills.

Students will write report of career exploration results.

Tuesday, June 29

Objective: Using mechanical writing skills correctly, developing and using creativity in writing, organizational skills. Using information from morning science lab on digestion, students will write a science fictional journey through the digestive tract.

Wednesday, June 30

Objective: Write an incident report, using words and terms that are precise, accurate, and appropriate, with emphasis on simple, nontechnical language, easy to read and understand, correctly spelled.

Students will write two incident reports -- one based on an incident with a patient, the other based on an on-the-job injury to student's finger.

Thursday, July 1

Objective: Understanding, interpreting, and using examples of terminology and abbreviations used in the health occupations field.
Skills include reading and interpreting written material precisely and accurately; writing medical terms and abbreviations into easy-to-understand nontechnical language.

Activity 1 - Students will be given information from a patient's chart which is written in medical abbreviations and technical medical language. Given a glossary which lists a few of the terms and abbreviations from the medical field, students will write the chart into easy-to-understand terminology.

Activity 2 - Students will use a similar patient's chart written in layman's terminology and convert it to medical abbreviations and terminology.

Friday, July 2

Objective: In preparation for interviewing person employed in Mechanical Design field next week, students will brainstorm appropriate questions to ask during interview.

Tuesday, July 6

Objective: Interview person who works in Mechanical Design field, using questions developed last Friday. Skills: Note taking, interviewing skills.

Wednesday, July 7

Demonstration of CAD-CAM Lab

Thursday, July 8

Write report of interview and CAD-CAM Lab

Summer Institute Evaluation

A list compiled by participating students and teachers

1. Growth, achievement, progress in subject matter
2. Attendance
3. Class participation
4. Attitude
5. Team work
6. Ask questions
7. Responsible for one's own actions and learning
8. Follow safety rules

Curriculum Maps

Curriculum Mapping for Associate Degree

and Vocational Diploma Programs

at Blackhawk Technical College

Created for
a smooth transition from a high school program to a
technical college program

Resources in Vocational Education (RIVE)

AN **ID** State; Proposal **ST** WI **FY** 93 **FS** CD Curriculum Development
NO GN: 05-485-150-613 **CD** **AL** **PI** WI93CD05
TI Services to the Disadvantaged-Curriculum Development

PD **Phone**

ON Blackhawk Technical College
AD 6004 Prairie Road, P.O. Box 5009 Janesville, WI 53547-5009
OT 07 Community/Junior College or Technical Institute
SA
DT 01Jul92; 30Jun93 **FF** 93; 23461 **TD** 0
P **DN**
E 07 High School and Postsecondary (10-14)
TP 08 Student
PP 21 Curriculum
P 05 Printed Instructional Materials

Contact WI1
James Halloran

Date Recd 9/29/94

AB The project will develop secondary through technical college curriculum maps for programs offered by Wisconsin's Blackhawk Technical College District. Each map will identify a recommended competency level for persons interested in enrolling in a specific postsecondary program and, for some, identify the recommended high school courses by year and postsecondary curriculum. Maps will cover programs from Associate Degree Accounting to Short Term Certificate Nursing ASsistant. Also, the project will develop three competency-based applied course curricula from postsecondary programs with high concentrations of academically disadvantaged students. The curricula will be for math, science, and communications.